DISCOVERY

Monthly Note Book
D. S. EVANS, M.A., Ph.D.

Feb. '43

Darwinism To-day
J. S. HUXLEY, F.R.S.

Scientists in Conference

Explosions in the Sky
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Surgery of the Brain

From Straw to Paper
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Air-Line Engineering Management, VII. (*concluded*) Ivor Lusty.
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THE MAGAZINE OF SCIENTIFIC PROGRESS

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Planning Science

THE Conference of the Association of Scientific Workers held in the Caxton Hall, Westminster, on January 30th and 31st, dealt with the subject of the planning of science. There can have been few more controversial issues in scientific circles in recent years.

On the one hand there is the contention of the group of scientists, chief among whom is Dr. John R. Baker, who consider that any proposal for the planning of science is bound to interfere with the traditional freedom and right of choice of work of the scientist.

On the other, the Association of Scientific Workers has taken the view that the planning of science is essential for the successful prosecution of the war, and this body also considers that such a policy could, with advantage, be continued even in peacetime. That there is reason in the first part of this argument there can be little doubt. Scientific resources both of personnel and of material equipment in this country are not unlimited. The number of scientific problems which daily press in upon our scientists and technicians is so large that some priority system would seem to be essential for the most effective utilization of those resources.

It is true that many of these problems are so vital that the need for their speedy solution cannot be missed. It is probably true to say that the present system is reasonably adequate to ensure this but there remain nevertheless many urgent war problems whose urgency is not so immediately apparent, and it is much less certain that we have succeeded here in avoiding omission, or duplication of work by competing firms or government departments, or even separate Governments of the United Nations.

Some measure of planning for war purposes already exists. The proper mobilization of scientific man-power is the province of the Central Register. It is in the field of the formulation of new problems and the allocation of their study to research teams with facilities and experience adequate for their successful and speedy solution that we are most deficient. Even here there are distinguished exceptions, and the many research programmes carried out under the direction of the Medical Research Council are in many ways a model of what planned science might be.

However, the extent of the dissatisfaction which is felt with the present state of affairs may be judged by the considerable support which was given to the Private Members' motion which it was hoped would have been debated in the House of Commons. The proposal contained in that motion was for the establishment of a Central Technical Planning Committee or "Scientific General Staff" composed of men with scientific experience, which would have had the powers necessary to enable it to carry out the essential functions of the allocation of priorities, the assignment of problems to competent groups of workers, and the abolition of duplication, competitive work and the retention of trade secrets to the detriment of the war effort. It is inevitable that the establishment of such a body would involve some restriction on the freedom of activity of the scientist if only in the sense that it would make his work a more efficient weapon of war. On the other hand, given the war situation, it would increase the reality of the freedom of the scientist by affording him direct access to an organ of government equipped with the powers and information necessary to enable it to adjudicate on the merits of any scientific proposal and to ensure its speedy translation into practice.

The continuance of such a scheme in peacetime is a more thorny problem. To-day we may be thinking in terms of the manufacture of synthetic rubber and other substitutes: of the problems of war agriculture and of the most effective utilisation of our coal resources. In peacetime we may be thinking of problems of public health, or of the long-distance transmission of electric power: we shall too, as the result of the recent allocation of a total grant of £1,000,000 to the British Coal Utilization Research Association, be considering our coal problems against the new background of the peace. Just as the present lack of

formal organization in British science is not well adapted for war purposes, so may that same lack endanger the prospects of reconstruction.

Opponents of such a reorganization have seen in it a slavish imitation of the Soviet Union and have made great play with the dictum that in that country no distinction is recognized between "pure" and "applied" science. They have asserted that any form of planning will so hamper the individual initiative of the scientist as to reduce him to the level of a mere technician. That this is a misconception can be seen at once when one recalls that it is impossible tocarry out successful research intended for practical application unless the fundamental "pure" scientific knowledge has already been obtained. The experience of, for instance, the Bell Telephone Research Laboratories in the U.S.A. is a demonstration of how closely the two are linked together. Any system of planning must be designed so as to preserve the freedom and initiative of the individual scientist. That this is possible even on the international scale is demonstrated by the experience of the International Astronomical Union, which was compelled, from the very nature of the scientific material which it handled, to organize, from time to time, large scientific projects requiring the co-operation of astronomers from all over the world. Perhaps the best example of such free planning was the great international project organized for the observation of Eros in 1931 when observatories from many nations co-operated in the determination of the scale of the solar system.

To-day and in the future the proper organization of science will be a matter of considerable social importance, and the Association of Scientific Workers has made a valuable contribution by giving an opportunity to all scientists of presenting their views on this important subject.

Raised Blood Pressure

RESEARCH work on the subject of raised blood pressure has made rapid progress during the last ten years: during the last year there have been clinical trials of a substance which looks like being as important for this disease as insulin is for diabetes. Moreover, this has been one of those satisfying lines of research in which the steps of progress have been guided by logic and not by luck.

Raised blood pressure, or "hypertension", occurs in two forms. The "benign" form typically affects the over fifties: indeed, in them, some raising of the blood pressure above the accepted normal limits is regarded more as the rule than the exception. But that this is only a relatively "benign" condition is shown by the fact that at least 25 per cent of those affected eventually die directly or indirectly as the result of the state of their blood pressure, the high level of which means that their arteries are unceasingly under an excessive strain. In addition, during their lifetime, the activities, both mental and physical, of the sufferers are drastically limited by the condition.

The "malignant" form of hypertension typically affects young people: is characterized by obvious damage to the kidneys and eyes, and runs a rapidly fatal course. In the past there has been little that medical science could advise in either form of the disease, beyond commonsense measures which the patient could think out for himself, and little in the way of advice which was not extremely irksome to carry out. This was the disease that caused a great pathologist who suffered from it to exclaim, in barely suppressed fury, that his very life was at the mercy of every fool that chanced to annoy him.

That there was a connexion between the kidneys and the blood pressure level had been established by the end of the last century. Various disorders of the kidneys, loosely included under the heading of Bright's disease, were known to be associated with hypertension. As early as 1898 Tigerstedt and Bergman had extracted from normal rabbit kidneys a substance which they called renin, which had the property of raising the blood pressure of animals into which it was injected. However, these early clues were not followed up by any further advance for over a quarter of a century. Then, Goldblatt, working in America, succeeded in raising the blood pressure of dogs by reducing the blood supply to their kidneys. His work, first published in 1934, has been repeated all over the world, often with variations in technique, but always with the same result.

That Goldblatt's experimental results also applied to human beings was shown by a few rare cases in which a chance abnormality resulting in a reduction of the blood supply to one or both kidneys was associated with hypertension. It was also found that in humans too, the removal —where possible—of the affected kidney tissue frequently resulted in the return of the blood pressure to normal. Besides these few freak cases there were the results of the work of Moritz and Oldt, published in 1937, who made post-mortem examinations of 100 cases of hypertension, both benign and malignant. They found not only a much higher incidence of hardening and narrowing of the arteries as compared with the normal, but also a significantly greater concentration of these changes in the arteries of the kidneys. This work suggested very forcibly that a reduction in the blood supply to the kidneys might be the important factor in the production of hypertension in human beings.

The implications of these various items of medical knowledge, and the mechanism by which they could be explained, were finally worked out independently by Page and his associates in North America, and by Houssay and his co-workers in South America. None of the substances concerned has yet been isolated in pure form, and there are difficulties of nomenclature, but the essentials of the situation are as follows.

The maintenance of normal blood pressure depends, among other things, on the possession of normal kidneys, whose cells secrete into the blood the substance renin (sometimes called hypertensin), and also anti-renin whose action is exactly the opposite. When the kidney cells receive a reduced blood supply, the balance between the production of these two substances is upset in favour of renin, and the blood-pressure is raised. By a special method, Page has produced from normal kidneys an extract whose content of anti-renin is high, and which therefore lowers the blood pressure in dogs which have been given artificially raised blood pressure. In human beings it has been found that daily injections of Page's extract have produced a marked improvement, especially in cases of malignant hypertension. It is to be hoped that this work will be continued so that when it is well established it will be possible to produce the natural antidote to hypertension on a commercial scale.

Professor Pavlov's Pupils

A COMMUNICATION has recently been received from Professor P. Anokhin of the Neurophysiological Laboratory of the Soviet All-Union Institute of Experimental Medicine, under the title of "The Development of I. P. Pavlov's Scientific Legacy". This communication, which was sent by the Soviet Scientists Anti-Fascist Committee, is a discussion by one of his pupils of the development since his death, six years ago, of the work initiated by the great Russian physiologist.

Pavlov, it will be recalled, was responsible for the development of the modern concept of conditioned reflexes, and in his experiments on dogs he showed that in time the normal responses of salivation and other effects at the prospect of food could be elicited by, for instance, the sound of a bell, if by previous training the dogs had been made to associate this sound with the presentation of food.

The fact that such associations can in time be built up provided a new and more clear understanding of the way in which various types of association are built up by the brain. As Professor Anokhin remarks: "this, literally speaking, is 'a window into the brain' through which the experimenter may peep and follow up all the changes undergone by the cortical activity."

However salivation is a comparatively crude index to the animal's response, and one of the lines of work taken up by Pavlov's pupils since his death has been the effort to assess the more subtle features of the animal's behaviour. In particular reference is made to Professor Anokhin's own work in which he used two alternative troughs of food placed side by side.

By this and other methods a more complex pattern of behaviour could be readily studied, and the writer found that the destruction of the cerebral cortex in an animal possessing a number of conditioned reflexes affects differently the conditioned secretion and the more advanced behaviour, such as the choice of a particular trough.

Work on the finer hues of behaviour has also been undertaken by Dr. Shumilina at the Moscow Brain Institute, mostly in connexion with the frontal lobes of the brain. It is known that injury to this region in man leaves mental activity superficially unchanged, but has important effects on the more subtle features of behaviour which form so essential a part of personality. In dogs whose frontal lobes had been removed, there was the same distinction between the conditioned reflex and the motor choice. The conditioned secretion was restored within a few days, whereas the capacity of motor-conditioned reactions such as the choice of one trough or another was impaired for a very much longer period of time.

To avoid accessory stimuli associated with feeding, such as the sight of the food, its smell, or the noise produced by the trough, Professor Kupalov has adopted a method of feeding sugar solution directly into the animal's mouth. Professor Bykov has concerned himself with the study of the relation between the cerebral cortex and the internal organs, and has succeeded in producing changes in the activity of the kidneys, the spleen, the stomach, and so on in response to a stimulus such as the ringing of a bell.

Professor Rosenthal has studied the location in the brain of the mechanism responsible for various types of conditioned reflex activity, and finds that the mechanism is not strictly located but involves a whole number of distant nervous formations.

In addition, electrical methods for the study of the behaviour of the brain have been used, and Dr. Laptev, working in Professor Anokhin's laboratory, has carried on investigations of the electrical changes in the brain using electrodes applied directly to the cortex, by healing them up into the skull. In this way the propagation of the nervous impulses associated with the application of conditioned and unconditioned stimuli may be studied.

Studies have also been made of the development of conditioned reflexes in new-born animals, and it was found that if a guinea pig embryo was withdrawn prematurely from the uterus, six or eight days before the normal time of birth, a perfect conditioned reflex could be established in it. It is concluded from this and other work that in some cases the *form of the reaction* is acquired after birth, while the associations of the cerebral cells necessary for this reaction are prepared long before birth.

Clinical applications have also been made of the results of this type of research, Professor M. K. Petrova found that certain pharmacological substances such as bromides and sympathomimetin alter the cortical activity in that they restore the efficiency of the cerebral cells. Conversely by depriving the animal of some hormones, cortical activity can be reduced, so that the cerebral cells prove incapable of a perfect reaction to the conditioned stimuli. Professor A. I. Dolin has succeeded in elaborating conditioned reflexes to a number of pathological states which can be produced by poisoning with various substances, and he finally succeeded in producing tetanic fits and the cataleptic state by conditioned stimuli alone. In such experiments there lies the hope of being able to cut off the pathological states as well as being able to elicit them.

In this field also falls the use of prolonged narcosis for the treatment of the grave mental disease called schizophrenia, and in his clinic Professor Ivanov-Smolensky has been using a treatment in which a continuous 12 to 15 days' sleep was induced.

It is a happy augury for the future that so much important work is being undertaken in this field by the scientists of our great ally.

Tuberculosis, Physics and Sociology

IN the last issue we described a new method for the treatment of tuberculosis. However successful that may be, it will always be the case that tuberculosis is a serious problem whose incidence is encouraged by the wartime conditions of overcrowding, restricted housing accommodation, poor ventilation, and so on. It will always be important, too, to have a means for the reliable early diagnosis of tuberculosis, for this disease will always prove more tractable in its early stages.

The technique of mass radiography is not new to any audience which follows the news. It means simply the taking of radiographs, i.e., X-ray photographs, of the lungs of large groups of people. This is done, not by the use of the ordinary large-size film which measures 14 × 8 in., but by the very much cheaper method of photographing the image of the chest produced by X-rays on a fluorescent screen, using ordinary 35-mm. cinematograph film. This is the same size as the film used in many of the modern

[Courtesy du Pont Company

A cheek retractor made of a curved transparent plastic rod, with concentrated light coming out at the end.

miniature cameras, and enables very large numbers of radiographs to be taken at a very low cost. They are nevertheless large enough to enable a medical man to diagnose tuberculosis of the lungs or to order further and more detailed investigation in suspicious cases.

The technique of the method involves certain physical considerations which may be new to readers. In the first place the luminosity of the fluorescent screen is low, and a high performance is thus required both in the X-ray tube and the camera. In addition the exposure must be short so as to minimize the risk of the subject moving, and this puts an additional strain on performance. For this reason the film must be made as fast as is consistent with good contrast and reasonable grain size, although the latter interlocks with the problem of lens design, since there is no point in making the grain size much less than the finest definition given by the lens.

For 35-mm. film, a focal length of about 2 in. corresponds with miniature camera practice, and an aperture of *f*/1·5 is generally satisfactory, although *f*/1·9 and *f*/0·9 have both been tried. Another reason for attempting to increase the photographic sensitivity is to make it possible to reduce the loading on the X-ray tube. It must be realized that there is an expenditure of energy of from 6 to 18 kilowatts on a target area of only one or two square millimetres. Such a load is made possible only by the use of a rotating anode, which spread the target over a circle instead of a single spot. Even so, such a load can only be maintained for brief exposures, and in addition the long-period average dissipation must be kept down, so that the heavier the exposures, the fewer can be made per hour.

Of all the kilowatts of energy going into the X-ray tube an infinitesimal amount appears as light from the fluorescent screen, and the energy losses are very heavy at each stage. First, most of the energy of the electrons which bombard the target of the X-ray tube is dissipated as heat. Then the X-rays generated cannot be focused, and the limited beam of radiation which is used is only obtained by sacrificing the energy radiated in all other directions by absorbing it in lead screens. Finally only a small percentage of the energy which reaches the fluorescent screen is converted into light. The energy which goes into an X-ray tube is enough to light a street, but all that comes out is just sufficient to illuminate an area 16 ins. square just bright enough to be photographed with a very fast camera.

In addition to these problems there is the requirement of an accurate record system to ensure that each film is correctly numbered, and that the film always turns on through just one space.

When the radiographs have been obtained they are projected to a size of about 5 ins. square and are examined by a radiologist. In practice the speed of the examination of large groups of people is likely to be limited more by the rate at which films can be examined than anything else.

The results of mass radiography are likely to be very far-reaching. The fact that a recent report shows that among R.A.F. personnel who have passed a medical examination, there still remains a residue of 0·27 per cent of active tuberculosis cases, means that about a quarter of the active tuberculosis cases were not detected by ordinary medical examination, and shows how much remains to be done.

Results from America show that among employees of the Eastman Kodak Company tuberculosis has been reduced from 2·3 per 1,000 in 1921 to 0·2 per 1,000 in 1940, and some at any rate of this decrease must be put down to the employment of mass radiography.

The earlier the detection of the disease, the better the chance of recovery. Figures for the staff of the Metropolitan Life Insurance Company of New York City show that in the absence of annual examination only $\frac{1}{8}$ of the cases of tuberculosis were discovered at an early stage, but now the proportion is $\frac{3}{4}$, and $\frac{4}{5}$ of those diagnosed at an early stage recover sufficiently to return to work and stay there. We may contrast these figures with those of the L.C.C. for 1933. Out of 3,446 adult patients with pulmonary tuberculosis discharged in that year only 43 per cent were alive five years later.

The examination of the entire population could be

accomplished with about 500 sets of equipment. At first there would be a large increase in the number of cases requiring treatment due to the greater efficiency of the method of detection. However, if mass radiography is to play its full part in the improvement of the health of the community it will be necessary to link it with full financial provision for the families of patients. The final cost to the community would be far less than that entailed by present circumstances which discourage a sufferer from undergoing treatment and encourage him to try to carry on with his work, mixing with and infecting his fellows. The Beveridge Plan would achieve this, and part of its value would be to make mass radiography an effective weapon in the fight against disease.

Plastics and Medicine

The use of so-called plastic materials for the manufacture of gramophone records, telephones, and electric light fittings is a familiar feature of modern life. There are two types of plastics; thermo-plastics in which the shape can be altered at any time by the application of heat and pressure after they have been already moulded, and thermo-setting plastics which undergo an irreversible change in the manufacturing process which makes it impossible for them to be moulded again. Typical examples of thermo-plastics are celluloid and naturally occurring resins and waxes. An example of a thermo-setting plastic is that made from the casein of milk which "takes" dyes very well and is suitable for making highly coloured cups and plates. Among the earliest synthetic plastics were celluloid, first produced in 1865, and that made from casein, first prepared in 1897. To-day a multitude of synthetic plastics can be manufactured, and the variety of articles into which they can be made is legion.

Plastics were first taken up by the electrical industry, and it was by this channel that they made their entry into the medical world because of their value in the construction of electro-medical apparatus. The face and dials of the diathermy set, the fittings of the X-ray plant, the casings of a hundred and one instruments are all made of some synthetic plastic.

One of the most important plastics from the point of view of medicine is a transparent plastic which is formed from acrylic acid and the methyl part of methyl alcohol. The accompanying photographs show how this plastic can be used for dental purposes. The retractor shown in the first photograph can of course be used for the examination of any part of the body or in operations where even with the best shadowless lamps it is impossible to get enough light at exactly the spot where it is needed. This plastic is very resistant to corrosive fluids and thus a mouth retractor made from it is resistant to saliva. It is much tougher than glass and transmits more light. A very large number of surgical instruments could be made to take advantage of this valuable substance. A modified form of this plastic has been used for many years for the manufacture of dentures.

The optical principle used in the devices shown in the photographs is that of internal reflection, which means that light in a dense medium cannot be transmitted into a rarer medium such as air if it strikes the surface at too acute an angle. Thus the light fed in at one end of the rod can never escape from it and is "piped" along to the place where it is needed. These devices are a happy example of the value of the application of a simple physical principle to medical technique.

[*Courtesy du Pont Company*

Piped illumination, bringing a powerful, sterile beam of light into the dental or medical operating room without heat or glare or danger of electric shock.

Darwinism To-day

JULIAN S. HUXLEY D.Sc., F.R.S.

In the first portion of this essay I pointed out how Darwin's two main contentions had been abundantly confirmed. The fact that evolution has occurred has long since become a part of general thought; and natural selection is now established as the main agency by which the course of evolution has been guided. Attention was also drawn to the new knowledge we now possess of which I may call the physical basis of evolution—the mechanisms of heredity and hereditary variation—and of the different kinds of evolutionary change to be found in the history of life.

In addition, the modern extension of Darwinism has enabled us to analyse the process of selection in a way that was impossible in Darwin's day. In the first place, the intensity of selection may vary very considerably, and this will be reflected in its results. Where a group is freed from the full normal pressure of competitors or enemies, it is enabled to evolve in quite unusual directions. The classical examples of this are found on remote oceanic islands. In such areas of biological low pressure, the few types which manage to find their way thither proceed to radiate out in many new directions. The classical example is that of the birds called sickle-bills (Drepanididae) on the Hawaiian archipelago (Fig. 9). Derived from some kind of honey-creeper, they have in their oceanic isolation evolved into no less than 18 separate genera, adapted to an extraordinary range of habits, from nut- to insect-eaters, from woodpecker-like types to nectar-sippers.

In the Great Lakes of Africa, nature has conducted a demonstrative experiment, by permitting powerful predatory fish to reach some lakes, but not others. The little fish known as Cichlids exist in all the lakes. Where predators are present, as in Lake Albert, only four different Cichlid species have evolved since the Ice Age; but where predators are absent, as in Lake Victoria, there are over fifty Cichlid species, adapted to many new habitats and ways of life. Predator pressure has a restrictive effect on the diversification of prey.

The same sort of thing has happened in Australia, where the early or marsupial type of mammal was isolated before the more efficient placental type had been evolved. Accordingly, as everyone knows, the marsupials in Australia have produced dozens of types, such as kangaroos, Tasmanian wolf, and flying phalanger, not found either living or fossil in any other part of the world (Fig. 10). Elsewhere the pressure of more efficient competitors has prevented this efflorescence, and only a few generalized marsupials, such as the American opossum, have survived.

The Australian marsupials illustrate another point. The Australian area is much smaller and less varied than the great land masses of the northern hemisphere where the higher placentals evolved. There is less scope for variation, less need for extremes of efficiency, so that general selection-pressure never became so intense. As a result, the Australian marsupials were not pushed so hard or so far along their lines of specialization as were the placentals; they were not forced to such a pitch either of bio-mechanical efficiency or of intelligence; and they at once go downhill and are threatened with extinction when they have to compete with introduced placental types.

Even more interesting are the recent studies on qualitative differences in the results of different kinds of selection, or, if you prefer, of selection operating in different circumstances. Thus a peculiarly acute competition takes place before birth among such mammals as produce several young at a time. More eggs are always fertilized than can survive to birth; there is thus an intra-uterine selection, which puts a premium on quick and vigorous growth, for any laggard embryos will fail to get their fair share of the available nutriment and will die and be resorbed or aborted. As J. B. S. Haldane has pointed out, this pre-natal rapidity of growth will certainly tend to continue after birth; and so the slow growth and prolonged infancy which makes human learning possible could never have been evolved except in a mammalian stock like that of the monkeys, where only one young is normally born at a time.

Haldane has also drawn attention to the interesting point that instinctive altruism, such as is shown by bees or ants, cannot be evolved except in social organisms where reproduction is confined to a limited caste and the altruistic types are sterile.

The most far-reaching conclusion deriving from modern analysis, however, is that the results of natural selection are not necessarily beneficial to the species, and may even be harmful. This apparent paradox is based on the fact that much of the struggle for existence is not directed

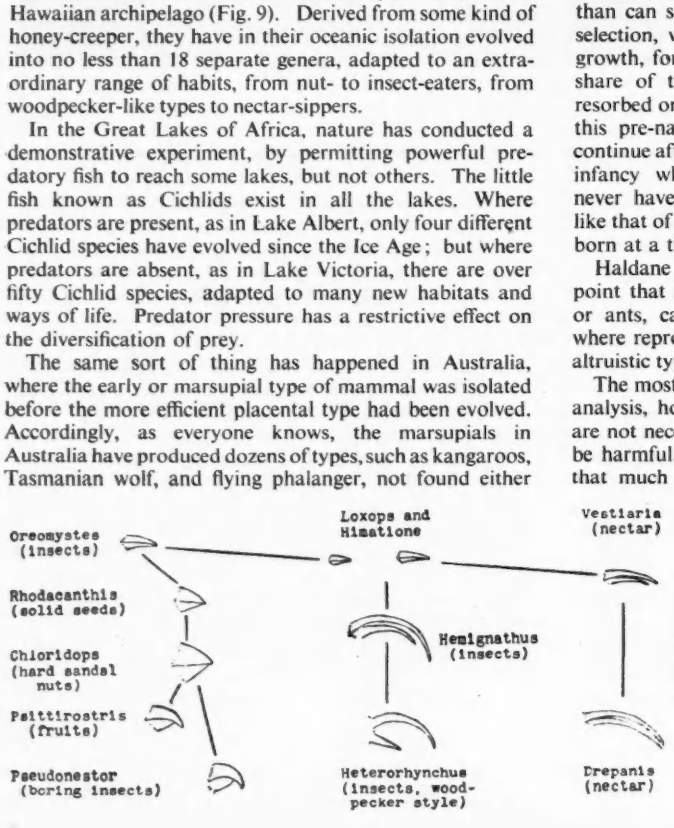


FIG. 9.—Beaks of various genera of the Drepanididae from the Hawaiian archipelago, showing the remarkable range of differentiation achieved by this family. Reproduced by permission of the Oxford University Press from R. Goldschmidt's *The Material Basis of Evolution* (Yale University Press).

FIG. 10.—Marsupial and egg-laying mammals only found in the Australian area. Left, from above downwards: Vulpine Phalanger; Rabbit-eared Bandicoot; Wombat. Centre: Kangaroos. Below: Spiny Ant-eater (Echidna). Right, from above downwards: Tasmanian Devil; Koala, or Native Bear: Duckbill (Platypus). (Reproduced by kind permission of the authors and publishers of *Science of Life* by H. G. Wells, J. S. Huxley and G. P. Wells, and the Waverley Book Co.)

against the forces of nature, nor against enemies, nor against competitors of other species, but against other members of the same species. Not only does the species as a whole have to struggle (in a metaphorical sense) to survive and reproduce, but so do the individuals within it. In a given species of butterfly, for instance, only a small proportion of the young caterpillars will survive into the butterfly stage. But among these, the decision as to which shall reproduce may depend, for instance, on whether one can escape detection by its enemies better than others. Accordingly protective resemblance, as for instance, of the famous Kallima to a dead leaf complete with imitation veins and mould spots, may be pushed to an incredibly high pitch, and yet have no effect on the survival of the species as a whole, which will be decided mainly by the capacity of the caterpillars to survive their much more numerous dangers.

Other examples of such "hypertelic" adaptations are seen in the leaf-fish (Fig. 11) which drifts up to within reach of its prey under the guise of a floating dead leaf, the sea-horse of the Sargasso Sea (Fig. 12), which resembles a bit of Sargasso weed, or the extraordinary plant-bug Heteronotus (Fig. 13) which carries about an imitation ant on its upper surface to scare off its enemies.

This *intra-specific* competition is most obvious when rival males compete for mates and most acute when polygamy prevails and success in reproduction thus brings a multiple advantage. When this is so, the characters which bring success in mating may become so over-developed as to embarrass their possessors in the struggle for mere existence, as with the train of the peacock or the wings—almost useless for flight—of the Argus Pheasant. Sexual selection here has benefited none but certain types of males as against others: its results for the species as a whole are harmful.

This distinction, it is clear, has great importance for human affairs. Apologists for the *laisser-faire* system on the one hand and for militarism on the other hand, appealed to the Darwinian struggle for existence as a justification. Now we realize that these forms of the struggle, far from being helpful, are either useless, in which case they will be also wasteful, or actually inimical to progress.

Space forbids more than the barest mention of the ways in which studies on development have illuminated some of the dark places of evolution. I will confine myself to two examples. The antlers of a stag, like the jaws of a male stag-beetle and many other masculine characteristics,

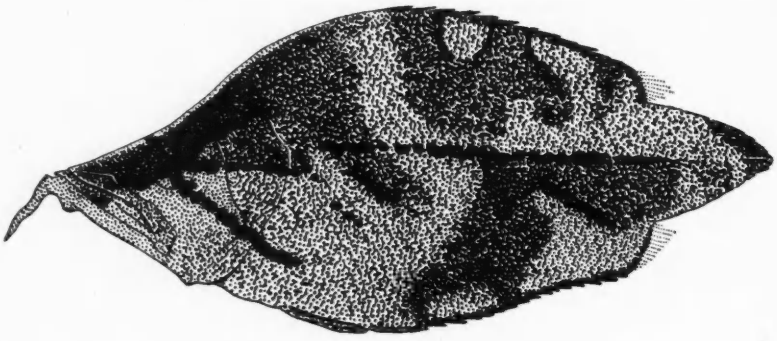


FIG. 11.—Leaf Fish (*Monocirrhus polyacanthus*) (Reproduced from *Adaptive Coloration in Animals* by kind permission of Hugh B. Cott and Methuen & Co., Ltd.)

FIG. 12.—Sea-dragon. (*Phyllopteryx eques*) (Reproduced from *Adaptive Coloration in Animals* by kind permission of Hugh B. Cott and Methuen & Co., Ltd.)

FIG. 13—Plant-bug (*Heteronotus membracidae*). Reproduced from *Animal Biology* by permission of J. B. S. Haldane and J. S. Huxley and the Oxford University Press.

increase disproportionately with the increase in the adult size of the animal. In a small stag, the antlers average about 2 per cent of his total weight. But in a large stag weighing twice as much, the antlers average almost 4 per cent—while the body has doubled its weight, they have quadrupled theirs

If now during the evolution of deer, selection takes place for increased bulk, there will be an automatic tendency for the antlers to increase in relative size (a conclusion borne out in general by the relative weight of antlers in species of deer of different sizes). Selection may also operate directly on antler-size, but so far as our automatic tendency is operative, change in relative antler-size is a mere by-product of change in general size. It is what Darwin called a "correlated character"—something useless in itself but correlated with some other character which is useful. We now know of a great many such correlated characters—for instance, tuning up or down the activity of one or other of the ductless glands to adjust the animal to its particular environment may produce changes in colour or in bodily proportions, and without question a great many apparently meaningless differences characterising related species or subspecies are mere external signs of such invisible but significant inner adaptations.

Another old objection to Darwinian explanations of evolution is the incredible complexity of the detailed adjustments needed to effect a change such as the lengthening of an animal's neck. To take but this one example, all the tendons tying the neck vertebrae together must be strengthened and their direction adjusted. How could random variation and selection account for this? We now know that the tissue of which tendons are made, like many other tissues of the body, has the faculty of responding to demands upon it both by excess growth and by changes in the direction of its fibres. Granted this one basic adaptation, all the rest follow. The myriad detailed adjustments are not determined by heredity and selection, but are built anew in each individual during its development.

In these and many other ways, our modern knowledge of growth and development has lightened the burden on natural selection, at the same time that advances in heredity have shown natural selection to be a much more flexible instrument than the last generation of biologists thought possible.

To sum up, Darwinism to-day is very much alive. In certain respects, indeed, modern evolutionary theory is more Darwinian than Darwin was himself. Darwin's special contribution to the evolution problem was the theory of natural selection, but owing to the rudimentary state of knowledge in certain biological fields, he was forced to bolster this up with subsidiary Lamarckian hypotheses, of the inheritance of the effects of use and disuse and of modifications produced by the direct agency of the environment. To-day, we are able to reject these subsidiary hypotheses, and can demonstrate that natural selection is omnipresent and virtually the only guiding agency in evolution.

Darwin has with some justice been called the Newton of biology. Like Newton, he gave his science a unifying concept, and one capable of extension into every corner of its field. There are evolutionary implications in every branch of biology. The human physiologist may provide the most detailed physico-chemical analysis of some bodily process: but his description will be incomplete unless he takes account of its evolutionary history as well.

The unifying power of the concept is also seen in the way in which the study of evolution makes a call upon the most diverse fields of biological study and links them together in solving its problems. Comparative anatomy, entomology, natural history and ecology, classification, palaeontology, genetics and cytology, the study of behaviour—all these and many more are now meeting and illuminating each other in the new evolutionary synthesis.

Evolution, too, was one of the first branches of enquiry to demand that relativist point of view which is becoming increasingly central to the modern scientific outlook. The single organism, looked at through evolutionary spectacles, has no meaning except in relation to a particular environment, to a particular set of enemies and competitors, to a particular past history, and to a particular set of potentialities for the future. All this was implicit in Darwin's masterly formulation of the problem.

The implications for man and for his general conception of nature and of his own place in nature, are equally far-reaching. The idea of a past Golden Age vanished into smoke; so did all static conceptions of human life. In their place we see inevitable change and possible progress, while at the same time the time-span of the human drama is enlarged a thousand-fold in the past and still more in the future.

Newton showed that the same general principles applied to the motion of heavenly bodies as to that of the humblest terrestrial objects. Similarly, Darwin with his few simple principles of the struggle for existence, natural selection, and consequent adaptation, linked man with all the rest of life, from monkeys and flowers to bacteria and amoebae, in a common web of necessity and change. The fundamental principles of Newtonian physics have now been superseded (though it still remains as the most effective first approximation to physical truth). Though Darwin's principles have been more modified in detail than Newton's, there seems less likelihood of their being superseded by a different set of basic principles. There are no signs that evolutionary biology will not indefinitely remain Darwinian.

Planning of Science in War and Peace

Association of Scientific Workers' Conference

CAXTON HALL was filled to capacity when Sir Robert Watson-Watt, pioneer of radiolocation and president of the Association of Scientific Workers, opened the conference on "Planning of Science in War and Peace" on Saturday afternoon, January 30th. In his introductory remarks Sir Robert remarked on the double task of the scientist at the present time. "That task is the education of our master, the public, in the things we might do for them were we permitted to do so. The reason for that particular bit of the task being forced upon us lies in the curious history of education," he said. "There was not only a schism between the humanities and science, but also between the scientists, for the engineer had thrown in his lot with the humanities by concentrating on the needs of man while the physicist investigated the forces of nature".

Sir Stafford Cripps, Minister of Aircraft Production, gave a detailed survey of the way in which science had been harnessed to war effort in this country. He said that the neglect of scientific organisation, and the failure to appreciate to the full the great part that science was bound to play in a modern war, led us, in the pre-war years, to neglect the organisation of the scientific side of war.

"We have not created a tidy blue-print plan of scientific organisation of the war effort, but have rather attempted to make the best use of our resources at those points where the resources seemed likely to produce the most valuable results in the quickest time," added Sir Stafford.

Central Planning Board

Mr. E. D. Swann, representing the Association's executive committee, said that in submitting proposals to Government departments in the form of a memorandum they expressed the view that the problems could not be wholly solved without the setting up of a Central Planning Board. Speed was as important as direction. Scientific information must be pooled, and there must be no deliberate withholding of trade secrets from the war effort. The Government must use its powers to demand the revealing of secret processes where necessary. It was essential for projects to come to fruition in time for their most effective use in the war, or to be abandoned in favour of a ernative projects. This necessitated the co-ordination of scientific work with the main war strategy.

SIR PHILIP JOUBERT, Inspector General of the R.A.F., was introduced by Sir Robert Watson-Watt as "the customer" who had to use scientific equipment. Sir Philip said it was a fallacy to believe that this war was the first time that science was helping the soldier. Perhaps the association of the soldier and science reached its highest pitch in the adolescence of the R.A.F., and acceleration had never been lost entirely.

Sir Philip referred to the development of operational research sections, the first of which was set up at Fighter Command in 1939. Bomber, Coastal and Overseas commands soon adopted the idea, and when America came into the war they were immediately interested in operational research. This type of research brought scientists into military headquarters, and among soldiers with a different outlook this was liable to lead to friction. The ideal situation was for the soldier, knowing the military problem, to state his needs and put his requirements to the scientist for investigation, for the scientist was not trained or experienced to exercise military judgment. But the scientist should not always wait until he was asked; he might have to elucidate the position by investigating the need itself as well as the requirements. The scientist as a newcomer might also be able to grasp a problem more clearly than someone who had lived with the problem, and many difficulties had been cleared away by operational research.

America, Russia and China

The organisation of science in America, Russia and China was described by Sir Alfred Egerton, Dr. David Shoenberg and Dr. G. Woo respectively. Sir Alfred Egerton, a member of the committee which advises the War Cabinet on scientific matters and joint Secretary of the Royal Society, said that in the U.S.A. research was on a vaster scale than here, and there was a somewhat closer link between industry and the Universities in this field.

Dr. Shoenberg, who worked in Professor Kafitza's laboratories in Russia before the war, said the successes of the Red Armies were partly due to the successes of Russian science which had been mobilised before the war. There was no shortage of suitable personnel and laboratories to deal with war problems. The vast scale of Russian research could be gauged from the fact that, when the Soviet was faced with the great problem of dealing with wheat rotting in enormous quantites, fourteen research institutes set to work and found the solution within a year. The decentralisation of research had been invaluable in meeting the exigencies of evacuating laboratories as the Germans advanced.

In the ensuing discussion Dr. P. J. Garner, a rubber chemist, deplored the fact that insufficient synthetic rubber had been sent to this country for experimentation, although these tests must be made as processing of synthetic rubber was as difficult as its production.

Dr. D. P. Riley advocated greater international collaboration between the rank and file scientists, and also that our embassies abroad needed the addition of scientific attachés.

Professor J. B. S. Haldane called for adequate contact between the laboratory scientists directly concerned with the problems of production and executive officers of the Fighting Forces.

Summing up, Sir Robert Watson-Watt singled out the general insistencs upon the importance of planning from below and the need for direct contact between executive service officers. "It has been a major part of the co-operation between the U.S.A. and this country that, while we did occasionally send benevolent old gentleman, like myself, to confer with equally benevolent old gentlemen in the U.S., the greatest work has been done by picking up an indispensable man at a very considerable sacrifice to the immediate effort, and sending him to America to talk to his opposite number there. The principal recommendation which I myself brought back from America was that we should cut the flow of cables and paper across the Atlantic and send live young men to talk to live young men over there," concluded Sir Robert.

Liaison in Research Work

Opening the second session the chairman, Mr. T. Halse, struck the note of realism when he said that the appalling conditions of our fellows in Europe and occupied Russia demanded efforts from British scientists not only for victory, but for the speediest victory. Scientists, as individuals, had responsibilities which must be met immediately. The passive and non-constructive attitude which used alleged inefficiency "higher up" as an excuse for inaction must be repudiated entirely.

The speakers who followed gave instances which showed the way in which improvements suggested by individual scientists could be carried into effect. Mr. Ben Smith, national organiser of the Association, dealt with the workings of joint production and advisory committees.

Col. W. C. Devereux, managing director of one of the leading firms manufacturing the light alloys used in aeroplane construction, drew on his experiences in his own companies which employ about 600 people in the laboratory and research staffs. In his works there was a direct link between the management and the laboratory staff through a technical committee and several sub-committees on which management, works executives and scientific workers sat together.

Mr. A. Dooley, speaking on the state of the chemical industry, welcomed the improvement in the exchange of information between industrial firms engaged on similar work. He instanced the pooling

[Continued on page 64

Explosions in the Sky

DAVID S. EVANS, M.A., Ph.D.

EVERY few years some astronomer, often an amateur who knows the constellations like the back of his hand, suddenly notices a star where a few days previously there appeared to be none. This type of appearance is what is called a nova or new star, a name which is misleading because what has actually happened is not that a new star has been created but that a star too faint to be seen by the naked eye has undergone a sudden increase in brightness. One such nova was observed at the end of last year in the constellation Puppis. Many others are known to history, and some have been so bright as to be visible in the daytime.

The brightening takes place very rapidly, and it usually happens that only about two days are required for the star to attain a brightness which may be as much as 100,000 times as great as that of the sun. After attaining its maximum brightness the typical nova fades away gradually with perhaps occasional temporary recovery, over the course of several months, and after about a year has usually becomes so faint that it is once more invisible (see Fig. 1).

Fortunately for us the distances of the stars are all very great and this sudden increase of heat and light can be viewed from a comfortable distance. What is happening to the star itself is a catastrophe of the first magnitude. The star has actually exploded and blown away its outer layers in the form of huge expanding shells of gas which move outwards with speeds which may be as much as 500 miles per second.

The methods by which this picture has been built up form a fascinating detective story. The stars are all at such distances that we can never see the gases moving outwards even with the aid of the most powerful telescopes. All that we can see is the sudden increase in brightness, and we must bring into action our most powerful weapon of investigation—the spectroscope.

If light from any source is passed through a narrow slit and then allowed to fall on a glass prism whose edge is parallel to the slit, a band of light will be seen which represents a separation of the light from the original source into its constituent wavelengths or colours. Thus, light which was wholly red in colour would give only a red patch, light which was wholly blue simply a blue patch, while white light, which is a mixture of all colours, gives us a long band coloured red at one end and blue at the other. This is the principle of the spectroscope which has to-day been developed to such an extent that it is one of the most powerful means of scientific investigation at the disposal both of the astronomer and the physicist.

If light from a star is analysed in this way it is found that the band of light is crossed in certain definite positions by dark lines, that is, the light from the star is deficient in these particular wavelengths. The spectrum of a star appears to the uninitiated eye to be a horrible jumble of these lines, but it has been found that each of the chemical elements produces a quite definite pattern of lines characteristic of it. Thus each element has its "trade mark" by which its presence in the star can be detected.

We can make use of the spectrum lines to derive other types of information. If the source of light is moving rapidly away from us it will appear slightly reddened; if approaching us, each wavelength will be changed slightly towards the blue. This is exactly the same effect as that which we notice when a rapidly moving train passes us. While it is approaching, the pitch of its whistle is slightly sharpened. As it passes us and begins to move away the pitch drops, and we can in fact determine the speed of the train by this change in pitch.

In astronomy we use the spectrum lines as markers of particular wavelengths. If the star from which they arise is moving towards us all the lines will be displaced from their normal positions slightly towards the blue; if the motion is one of recession the displacement will be in the opposite direction, and from its amount we can determine the velocity of the luminous source towards or away from us (see Fig. 2).

The Spectrum of a Nova

The spectrum of a nova is highly characteristic and unlike anything else which we encounter in astronomy. In place of dark lines we have bright lines, but the same rule as to their origin still obtains. It is the wavelength which gives the clue to the chemical element responsible for the line. It is the physical conditions in the star itself which determine whether that line will appear dark upon a bright background or as a bright line.

Throughout the nova outburst the lines of the spectrum are all displaced to the blue, which indicates that here we are observing shells of gaseous material which are being flung up towards us. During the initial brightening the spectrum consists of dark lines known technically as absorption lines, but after maximum brightness various sets of bright lines appear as well, indicating that they originate in extremely hot gaseous shells. The spectrum is a very complicated one, and may change from day to day. The bright lines, which appear some time after maximum, include those due to oxygen, nitrogen, neon, and sulphur, but the most striking feature of the spectrum is that the lines are often split up into a number of components, indicating that the lines originate in a number of distinct shells of hot gas, moving with different velocities.

It might be thought to be fairly simple to deduce from a long series of observations of the velocity of a shell just how far it had been ejected, but the complex structure of the observed spectrum lines is such that we can never be quite certain whether a given set of observations always refers to the same mass of gas. In spite of these difficulties of interpretation it seems certain that the gases must be ejected to enormous distances, which may be measurable in hundreds of millions of miles.

At the end of its crowded hour of glorious life the star

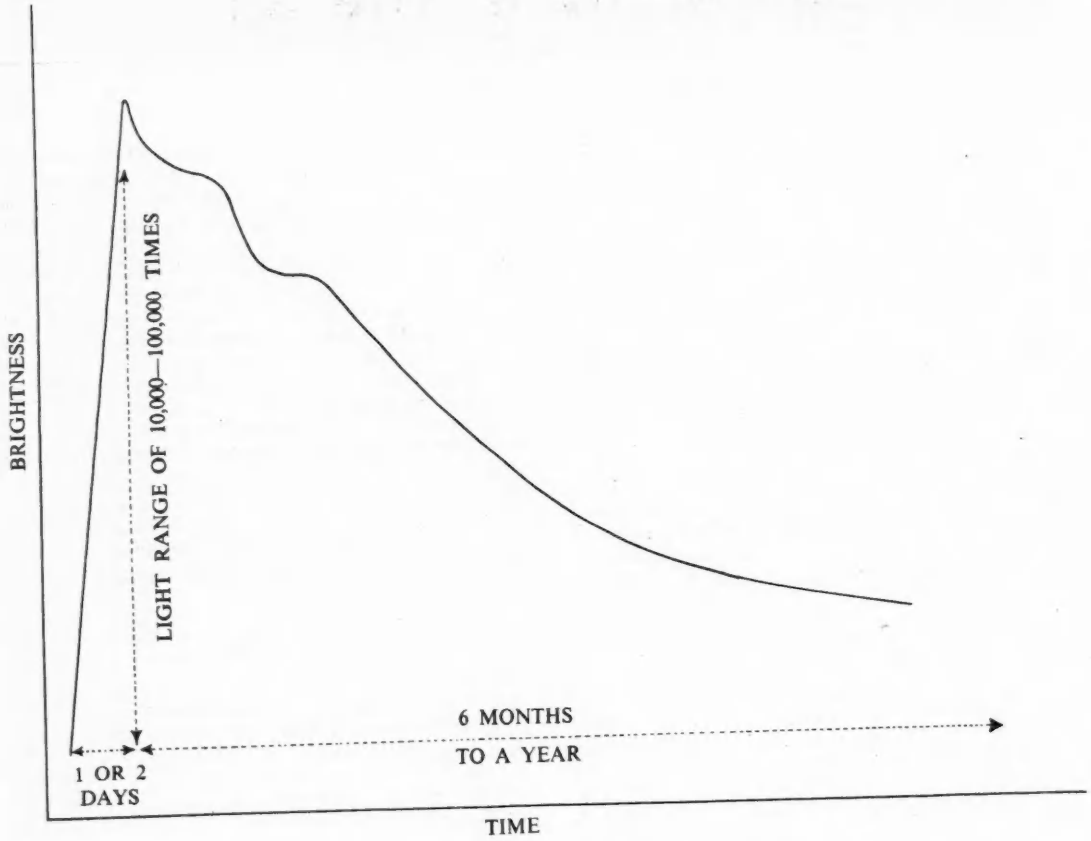


FIG. 1.—Light curve of a Nova.

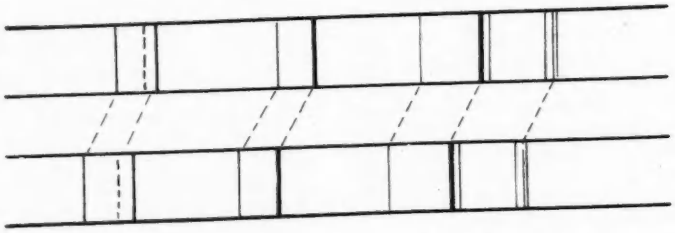


FIG. 2.—Displacement of Spectrum Lines due to Velocity of Source.

does not revert to its former state but retains a peculiar spectrum, very similar to that of a group of objects known to astronomers by the misleading name of "planetary nebulae". These objects are neither planets nor nebulae, but are stars of high luminosity with bright-line spectra which are seen to be surrounded by extensive envelopes of glowing gas. About 150 such objects are known, and it would be tempting to identify them with the end of the nova process. There are certain suggestive facts concerning planetary nebulae, besides the striking resemblance of their spectra to that of an old nova. Their shells of gas have been observed to be moving outwards, although the rate is only about ten miles per second, and moreover the distribution of planetary nebulae in space is similar to that of novae. The most serious objection to the identification is the scarcity of planetary nebulae. Unless —as some astronomers have suggested—the planetary nebulae represents a temporary stage only, there are far too few of them compared with the number of known novae.

The time during which we can observe a star is so short a fraction of its life that, even if this is the ultimate fate of a nova, we should lack the longevity needed for the continuous observation of the process. We are here presented with a problem in astronomical archaeology; we are able to observe what may be two stages in a long process, but life is too short for us to be able to follow that process through in the case of any one star.

Astrophysics is a science in which the research worker can rarely acquire exactly the knowledge which he needs, and the study of novae is particularly tantalising. Our understanding of the nature of these explosions would be much deeper if we knew what sort of star was subject to them.

The most serious difficulty is that no one has yet observed a star before it become a nova, simply because such stars are usually much too faint to have been observed at all, much less thoroughly investigated.

Two kinds of Novae

One serious difficulty is presented by the fact that actually there are two kinds of novae. There are ordinary novae whose brightness at maximum is about 100,000 times that of the sun, and there are supernovae which attain a brightness of about 70,000,000 suns. These two classes are quite distinct and there are no intermediate cases.

Ordinary novae are mysterious enough, but supernovae present a formidable puzzle. In many ways they seem to be similar to ordinary novae, only on a vastly greater scale; but here the similarity ends. The gases are ejected with speeds as much as 1,500 miles per second: the spectra are much more complicated, and interpretation is as yet an unsolved problem.

About a dozen such supernovae were on record up to the beginning of the war, and there is an historical record of two within our own galaxy. One, in 1054, which is mentioned in ancient Chinese and Japanese records, occurred at a point in the sky which is now occupied by the irregular mass of gas known as the Crab Nebula. It is conjectured that this nebula is in fact all that remains as the result of that cataclysm. The other, which occurred in 1572, was observed by the famous Danish astronomer, Tycho Brahe, and was bright enough to be seen in daylight.

In spite of the mystery which attaches to them, supernovae are likely to prove of great value to astronomers. Their enormous brightness, and the fact that this brightness is roughly constant from example to example makes them suitable for use in distance determinations.

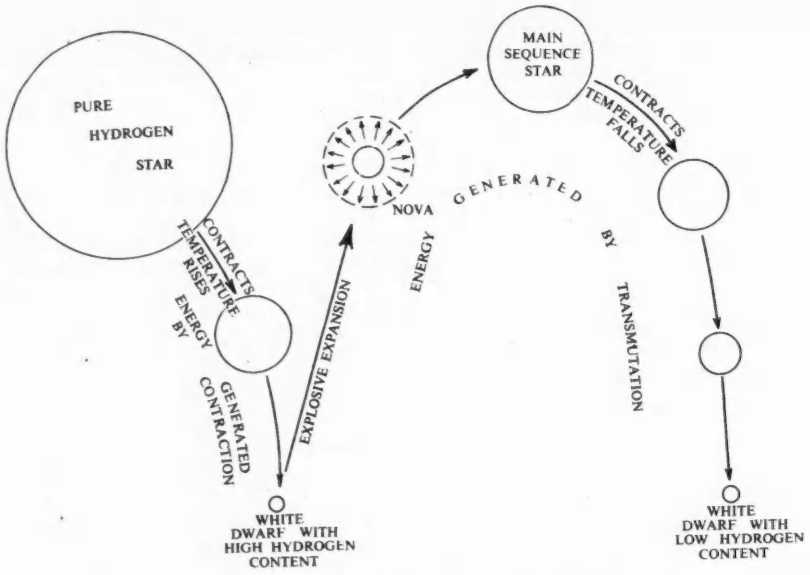
Supernovae have been observed in other galaxies besides our own, and at maximum the single star may emit as much light as all the millions of stars which make up that galaxy put together. Since it is known from other observations what that maximum brightness is, it is possible to estimate the distance of the supernova, and hence that of the galaxy in which it appears, by comparing this instrinsic brightness with the observed brightness. In this way reliable distance estimates can be obtained with an accuracy possible in no other way, for there is no other single class of object available for use in such estimates which is visible at all distances from the comparatively small to the most distant depths of space accessible to observation.

Even among ordinary novae there are examples which do not conform to the ordinary rules. The best investigated nova of recent times is Nova Herculis, 1934, which showed a very unusual light variation. Instead of fading away as a well-brought-up nova should, it perversely produced a new outburst just when the hard-worked observers had begun to think that it would be safe to take their annual holiday. The result of many months of arduous investigation was to produce hundreds of spectrograms of this particular star which have since been compiled into an atlas. This atlas is a wonderful storehouse which will require many years of study and which is likely to provide most valuable information as to the nature of these strange phenomena.

Generating Energy in Novae

While we do not know in detail why a star becomes a nova, we have some idea of the mechanism by which the process takes place. An ordinary star generates its energy in the deep interior by changes in the atoms of its material which can only go on at very high temperatures and pressures. The energy-generating process is remarkably sensitive to temperature. A very slight increase in temperature will produce an enormous increase in the output of radiation, and it is suspected that in the case of a nova this process somehow gets out of hand, with the result that the star literally explodes. What is the cause of this instability, we cannot say. Does this catastrophe happen only to peculiar stars or is it an event which normally occurs at some point or other in the life history of every star? If the latter is true, the phenomenon of the nova outburst has a certain parochial interest. One is tempted to inquire whether there is any likelihood of the sun's becoming a nova at any tine in the foreseeable future. The consequences of such an accident would be disastrous for our unfortunate planet, but we may reflect by way of consolation that stellar evolution must proceed at an extremely slow pace, and the probability of the catastrophe occurring within any particular century must be exceedingly small.

It is at this point that the theoretical astrophysicist



NOTE.—The range in size is actually much greater than that shown here.

FIG. 3.—One Theory of Stellar Evolution.

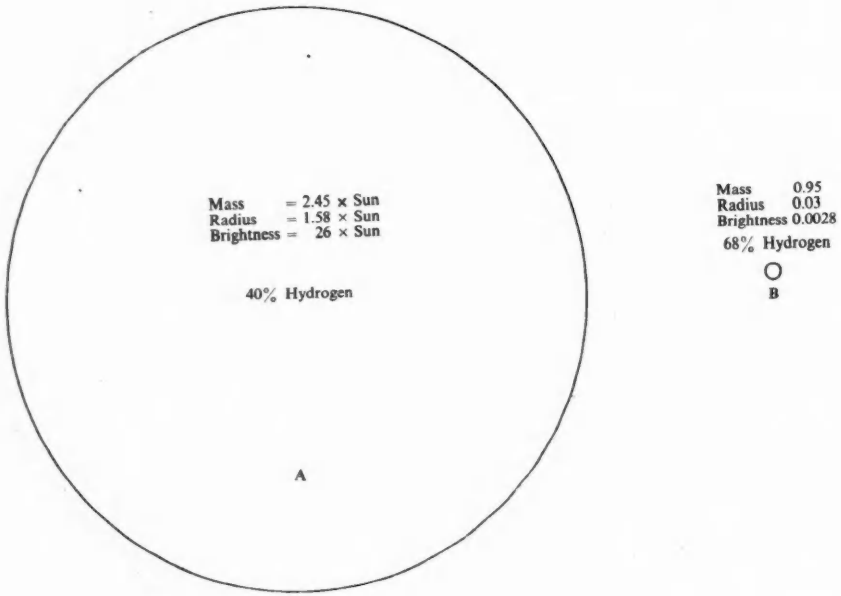


FIG. 4.—The Two Components of Sirius.

takes a hand. Sir Arthur Eddington has suggested a tentative theory of stellar evolution which provides an explanation of the phenomena of novae. Some years ago it was discovered that all ordinary stars contained an extremely high proportion of hydrogen which by conversion into helium must act as the fuel for the production of stellar energy. Recently Professor Eddington has investigated the hydrogen content of the peculiar stars which are known as white dwarfs. These stars have an extremely high temperature and are of rather small size, but the striking feature of their structure is their extraordinarily high density, which must be measured in terms of tons per cubic inch. These stars are extremely mysterious, and most astronomers were accustomed to regard them as having been evolved from ordinary stars by a process of contraction. This would mean that they were old stars representing the final stage of stellar evolution, and they therefore might be expected to have used up all their supplies of hydrogen. It was therefore most surprising that the result of Professor Eddington's investigations should have been to suggest that at least some of the white dwarf stars contained a very large proportion of hydrogen.

This meant that the white dwarf could not be the final stage of the story, and he put forward a possible sequence of stellar evolution which would account for this fact (see Fig. 3). He supposed that the initial stage was a very large and luminous star consisting of hydrogen and very little else. This would radiate energy and contract steadily, until the density became extremely high, and the star began to look like a white dwarf with a high hydrogen content. Under the conditions of high pressure and temperature new elements would begin to be formed in the interior of the star, and in particular it is possible that carbon and nitrogen might be formed. These two elements are the key substances or catalysts in the latest theory of stellar energy generation. They themselves are not changed, but their presence is essential for the transmutation of hydrogen into helium—a process which is believed to be the main source of stellar energy.

At first, the large hydrogen star would derive its energy not by transmutation but by contraction. This provides only a very limited supply, and so by stellar standards the star would contract rather rapidly. Once, however, the white dwarf stage had been reached, and the carbon and nitrogen had been formed, the star would switch over to an entirely new mechanism of energy generation, which would be very much more profuse in its output than the old one. The effect would be probably catastrophic, and the star would almost certainly expand with great rapidity. It is here, then, that on this theory the nova stage would occur, and it would thus represent a normal episode in the career of every star.

The theory goes on to suggest that after the nova outburst the star would appear as one of the normal inhabitants of space. It might indeed expand rather more than usual and become a giant star, of the type which is familiar to astronomers, but it is suggested that in the ordinary way it would become what is called a "main sequence" star, of a size comparable with that of our own sun. In later life it might be expected that the star would use up all its hydrogen and it would then once more begin to contract, ending up as a white dwarf, but this time with a very small hydrogen content. Support for this theory is given by the fact that such white dwarfs are known to occur.

On this theory every star would pass through a high-temperature stage three times in its career, of which the second would be reached by passage through the nova stage. The first stage, which would occur in the process of contraction from a globe of hydrogen to the white dwarf stage, would, it is suggested, correspond to a star similar to the nuclei of planetary nebulae. This theory therefore places the planetary nebula stage in a different position from that which was ordinarily thought to be the rule. Before, a possible explanation of the planetary nebulae was as the end product of a nova outburst; on this theory it precedes the nova stage.

It must be admitted that this theory does not clear up all the difficulties, but it does provide an explanation of certain very puzzling phenomena which were hitherto quite inexplicable. In particular it suggests an explanation for the very peculiar case of Sirius, which is a double star, one component of which is a very large hot star and the other is the famous white dwarf, the companion of Sirius (see Fig. 4). Investigation shows that the two components have roughly the same hydrogen content in spite of their great difference in type. If, as seems certain, the two components were originally united, it is extremely difficult to see how the fainter star can have a hydrogen content which is at least as great as that of the bright star unless we accept this theory, which would place the fainter star a little farther along the road which begins with the globe of pure hydrogen contracting into a white dwarf.

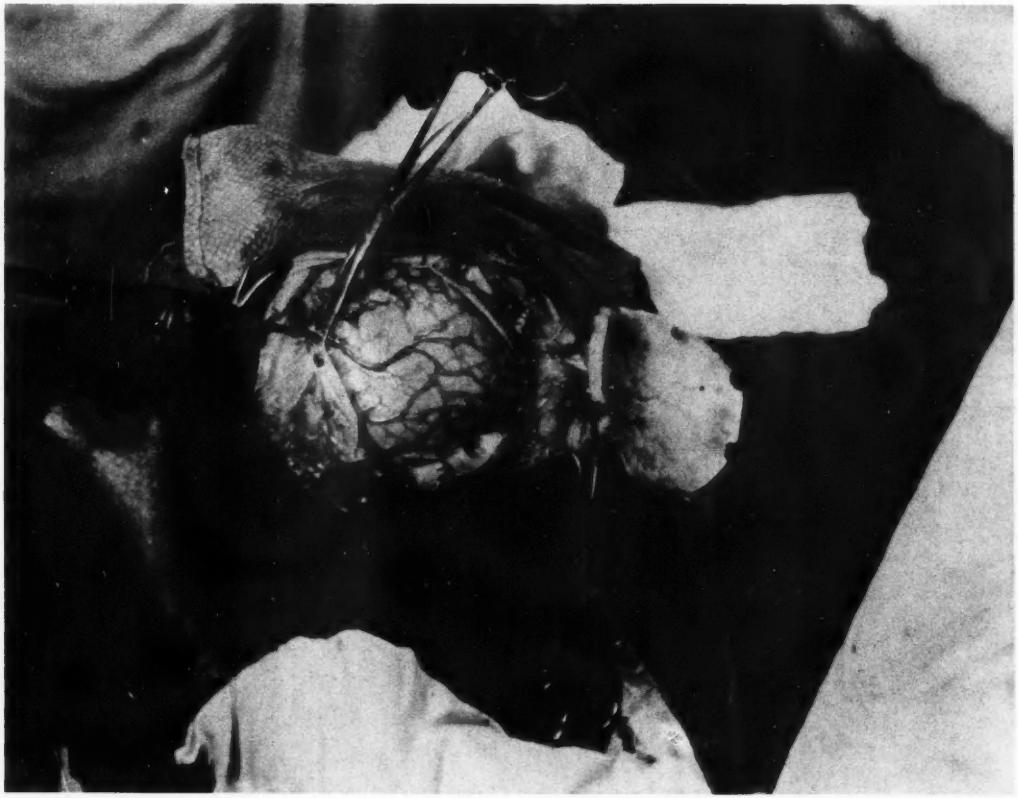
The theory is a speculative one, and this is inevitable in the present stage of our astronomical knowledge. Certainty is only possible in the study of astronomical phenomena as they appear now; our opportunities for observation are necessarily limited to a time which is infinitesimal compared with that required for any great development in the history of a star to take place. Nevertheless, it is essential for astronomers to attempt to assess these large-scale developments since they are full of possibilities for the better understanding of the behaviour of matter under conditions which cannot be imitated on the earth. Already the history of astronomy has given us many examples of how much fundamental knowledge of the properties of matter can be derived from the science of astrophysics. Our modern concept of the nature of the structure of the atom began to take shape with the first observations of the spectra of stars. That concept led in its turn to the development of the theory of stellar energy generation. To-day, astronomy has reached a stage when it seems likely that it will be able to contribute even greater gifts of knowledge to the general body of science.

Surgery of

THE operation of trephining, or trepanning, is one of the oldest of which there are definite records. Skulls attributed to the Neolithic period have been found showing apertures produced by a primitive form of trephining, and in some cases the condition of the bone showed clearly that the patient survived the operation. It is believed that the operation was then performed chiefly on epileptics or the insane, and that its purpose was to allow the devil, which was assumed to be the cause of the illness, to escape from the skull. The patient should thus be freed from "possession", with consequent relief of symptoms.

The possibility of operative treatment for diseases of the skull and brain has increased considerably during recent years, and operations are now performed successfully in many cases of tumour affecting the brain or its covering membranes and in certain cases of hæmorrhage within the skull. In comparatively few cases a tumour of the brain can be removed completely, but in almost all cases the abnormal pressure within the skull can be relieved and the symptoms thereby relieved.

Access to the brain was formerly gained by cutting through the skull with a trephine and the opening was then enlarged to the required extent by cutting bone from the edges of this opening with bone cutting forceps. The pieces of skull so removed could not be replaced. Not only was the bone to some extent crushed during removal, but also each fragment was completely cut away from its blood supply and therefore, if replaced, it was incapable of healing. After all such operations, therefore, the patient was left with a weak area in the skull. None of the many attempts to close this artificially, such as by screwing in a silver plate, proved entirely satisfactory. When the



the Brain

operation is done solely for the relief of pressure in cases of unremovable tumour of the brain the opening in the skull is, of course, allowed to remain, closed only by the skin and tissues of the scalp, thus allowing the excessive pressure within the skull to expend itself in pushing outwards the elastic skin in the form of a cerebral hernia.

If a tumour has been removed or hæmorrhage treated by operation, the condition within the skull can return to normal and in these cases the technique illustrated in the accompanying photographs is now used. A portion of skull of sufficient size is raised in one piece, together with its overlying tissues, and at the conclusion of the operation is replaced. As the blood supply is not completely cut off the bone retains its vitality and reunites with the surrounding skull. This method is known as the osteoplastic flap method. Four holes are drilled in the skull in the required positions, forming a rectangle, or, if a larger flap is required the number of holes may be increased. A small trephine is used for this purpose. The holes are then connected by cutting through the skull between each pair of adjacent holes with a Gigli saw. This, as is seen in the first illustration, is a wire saw which is passed inside the skull, using a guide to protect the underlying brain from injury, and worked to and fro like a fretsaw, cutting from within outwards. A stream of saline solution is played on the saw to wash away blood and bone debris. When all the original openings in the skull have been connected the flap is raised, still attached by its overlying tissues, and turned to one side. All bleeding points are clamped and after cutting through the membranes covering the brain the further stages in the operation can be commenced.

Jean Straker, the photographer of these remarkable illustrations, used a Contax II camera, with a Sonnar f2 lens stopped down to 2·8, working at a speed of $\frac{1}{5}$th second. The film was a Kodak Super XX fine grain, developed in Metol Meritor developer.

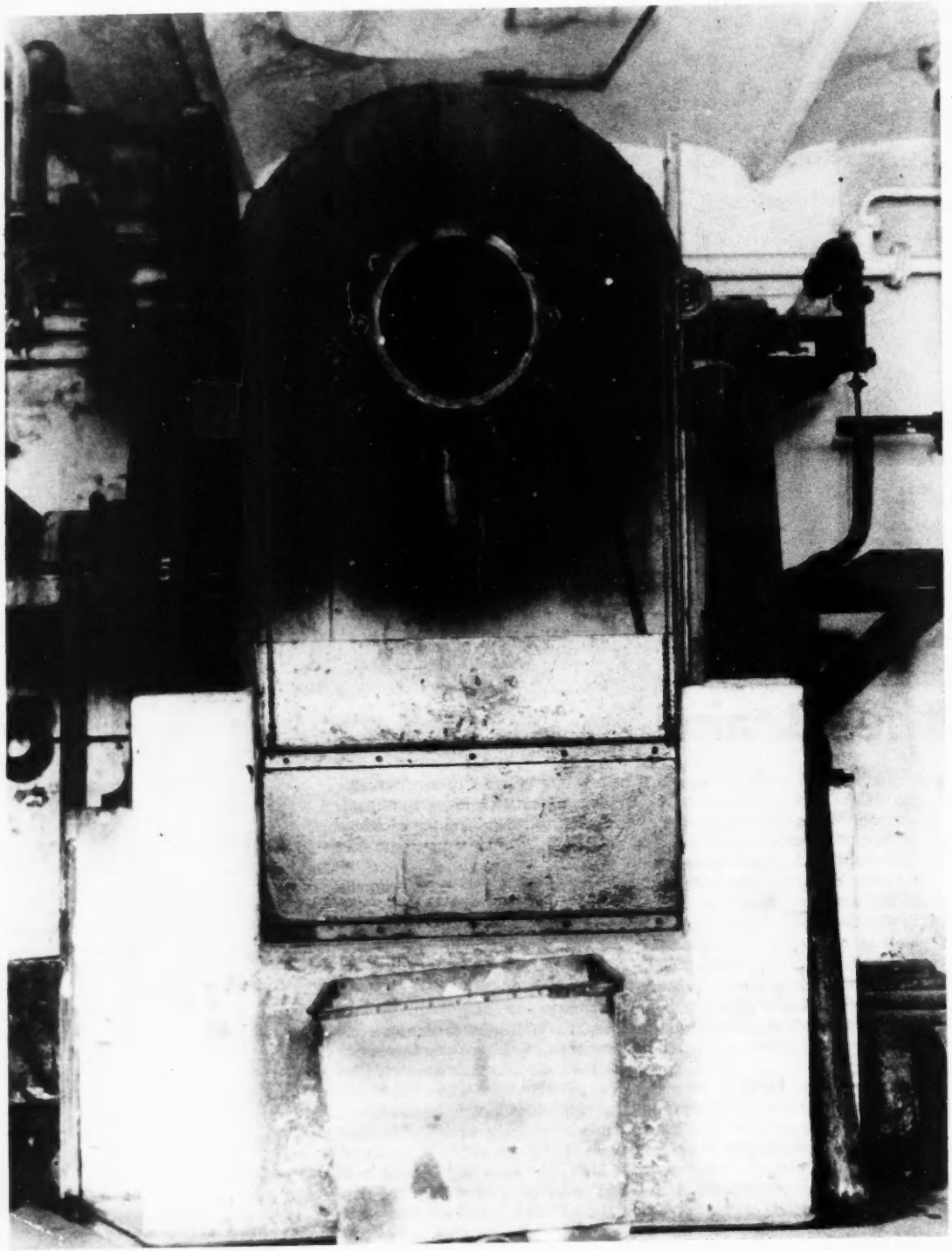


FIG. 1.—A Rag Boiler.

FIG. 2.—Straw (wheat) pulp (× 100).

From Straw to Paper

By JULIUS GRANT, M.Sc., Ph.D., F.I.C.

IN order to explain clearly the present position and future prospects of straw as a paper-making material it is necessary to go more than a century back in the history of the industry. The manufacture of paper in its true sense, that is as distinct from other writing materials such as parchment or papyrus, originated in China before the beginning of the Christian era. We can, however, pass over these early days very rapidly, because no problem of raw materials worried the paper maker then; "rags", old ropes, fishing nets, and the fibres from certain native plants provided much more than was needed to satisfy the demand for his product.

It was in fact not until about the beginning of the nineteenth century that the situation started to change, and two principal features influenced it. In the first place, the Fourdriner brothers in 1804 and John Dickinson in 1809, were able to show quite independently (and incidentally, at mills only a few miles apart, in Hertfordshire), how paper could be made in a continuous sheet or web, instead of by hand, a sheet at a time. Secondly, at about this time also educational facilities were beginning to improve, and this resulted in a greater demand for books and paper of all kinds. The paper-machine was of course, far better suited to meet this demand than the slow method of making paper by hand—but only so long as it had the requisite raw materials. At first the traditional materials, namely, chiefly rags, had to suffice, but it soon became clear that they could not meet this rapidly-growing demand despite even the exploitation of many unusual sources of rags. Thus, the linen shrouds from the dead were used and there was even talk of despoiling Egyptian mummies similarly, to keep the new paper-machines working.

Measures of this kind, however, could never be a complete solution to the problem, though strangely enough no one seemed to be particularly alive to this fact, since apparently it needed the incentive of money prizes (offered by *The Times* newspaper in 1854, and by the Royal Society of Arts) to stimulate research into a substitute for rag for paper manufacture.

After this offer suggestions came in more rapidly, and one of the first was straw (in about 1855). This, as a matter of fact, did not represent the first attempt to use straw as a material for paper manufacture. As early as 1800 one Matthias Koops had experimented (largely, one gathers, for his own personal interest), with the manufacture of paper from a great variety of what appear to us now to be a rather extraordinary assortment of materials. Nettles, thistles, manure, straw, hops, wood and wasp's nests figured in his collection, and he was able to demonstrate that all of these could be made into paper, although of course the quality of his papers varied considerably. However, he was so far successful with straw that in 1800 he published a book on an all-straw paper, dealing with his work, which he dedicated to George III. Matthias Koops was ahead of his time, and his work though of great historical interest, need not detain us, because it took little cognisance of the economics of the large-scale operation of straw digestion processes. The point to be

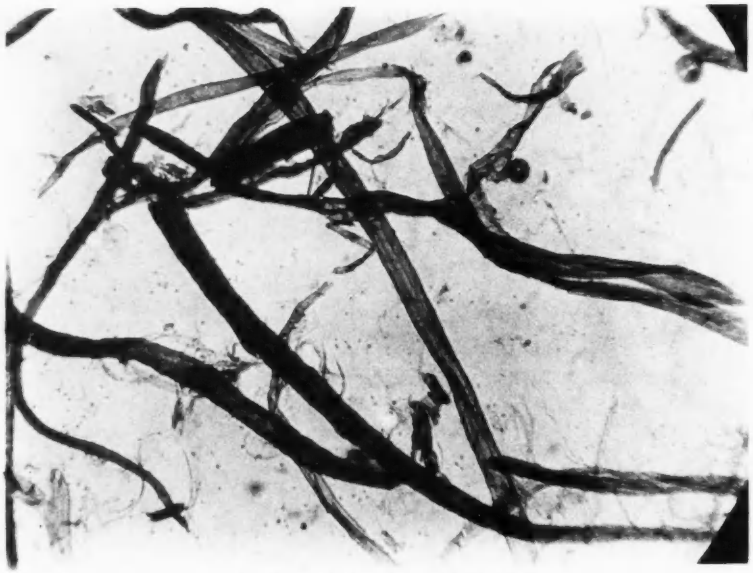


FIG. 3.—Sulphite wood pulp (× 100).

stressed at present is that straw was the first real substitute for rag on any scale in this country, and for a time papers made from rag and straw mixtures were quite common.

The incentive behind this work, however, did not spend itself on straw, and in particular other workers had been busily engaged in investigating the possibilities of wood. This is not unnatural, since, after all, wood was in abundant supply in the form of the great forests of the world, and as will be shown in more detail below, it has certain technical advantages over straw. The early history of wood pulp is a very interesting story in itself, since it demonstrates forcibly how a succession of difficulties and reverses were overcome by patient scientific investigation. From our point of view however, the important result is that a series of successful processes for pulping wood were evolved between 1860 and 1885, and since the resulting products catered for practically every type of paper in common use (an exception being the higher grades of papers, for which rag still stands pre-eminent), straw was gradually ousted from its place of precedence.

From that time onwards, apart from two interruptions due to the two World Wars, wood pulp in one form or another has supplied the bulk of the world's paper. There have, of course, been local exceptions. As might be expected, for instance, bamboo figures largely in papers produced in India, and another important exception, which is perhaps less easy to understand, is the use of esparto grass in Britain. This fibre was imported from the Mediterranean countries from about 1862 up to 1940, and when processed under suitable conditions it gives printing papers which cannot be surpassed for such essential qualities as flatness, good register, opacity, and receptivity to type and ink. British paper-makers have made a close study of the manufacture of esparto papers, with the result that their products were in demand all over the world, and in fact the esparto paper industry was exclusively British. This is an important point, because it has a strong influence on the present and future position of straw. It should also be mentioned that in Holland, which is mainly an agricultural country and where therefore there is an abundance of relatively cheap straw, this material has been processed in fairly large quantities for many years. Much of the better grades of this straw pulp was, however, exported.

The paper raw materials position in this country in September 1939 was therefore as follows. Our requirements were some 1,250,000 tons per annum. Of this about 80% was wood pulp, nearly all of which was imported (mainly from Scandinavia and Finland); 17% to 18% was esparto (imported from N. Africa and Spain); and the remaining 2% to 3% was made up of "other fibres" such as straw and rag, and much of this too was imported. A year later, we were cut off from all of these sources of supply. The position was obviously serious and there was no single complete remedy, although several possibilities were available. Firstly, there was the re-use of old paper, and paper salvage is now a very familiar feature of the war effort. Used paper is, however, necessarily inferior to new paper, and much of the lower grades of waste (which inevitably contain a proportion of good paper) must be used to satisfy tremendous appetites of the board mills. Moreover, there is a loss of yield each time paper is used, and this and the stringent economies in the use of paper remind us that there is a law of diminishing returns. A second alternative was to import wood-pulp from a friendly nation, and the United States (under Lease-Lend terms) and Canada especially have helped considerably in this respect. Such help, however, must always be severely restricted by problems of shipping space. The third and last "possibility" was that we should make pulp ourselves, and it is at this stage that straw came into its own again.

Now the manufacture of pulp from raw vegetable material requires high-pressure digesters, and since only those mills which processed esparto or rags before the war have such equipment, they are the only mills which can deal with straw. This is a point of great importance, since it explodes the many suggestions that other raw materials (often strongly reminiscent of those used by Matthias Koops) might solve the paper problem. The problem is, however, not shortage of raw materials, because our agricultural policy has given us an abundance of surplus straw, but the shortage of plant with which to process it. In fairness it should perhaps be mentioned that a certain amount of misunderstanding as to the straw position arose in 1941, owing to the late harvest and the

fact that the purchase and collection of straw for paper-making was at that time not fully organized. It was, in fact, about then that the wave of suggested other raw materials, such as bracken, peat, nettles, and so on, was at its height.

It might reasonably be asked why we should not pulp wood instead of straw. The answer is that our forest reserves are comparatively small, and wood is wanted for other important purposes; our trees (especially hard-woods) are not always suitable for pulping; high digester-pressures are required; and as already pointed out our present equipment is really intended for the much more easily processed esparto grass. However, a certain amount of wood waste (in the form of shavings, chips and offcuts from timber yards and lumber camps) is at present being pulped by those who have the equipment, and with a fair measure of success.

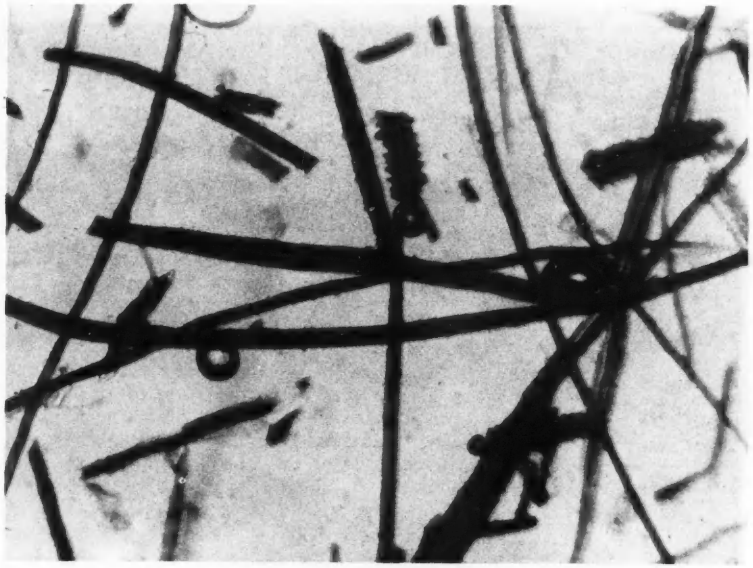


FIG. 4.—Esparto pulp (× 100).

Processing the Raw Material

It is now appropriate to deal with the actual methods used for pulping straw. These do not differ greatly from one mill to another, but for the reason already pointed out they are dictated by expedience rather than by real suitability. The paper-maker's real raw material is the substance cellulose, which has the composition $(C_6H_{10}O_5)_n$ and is contained in most plant materials in the form of white fibres, which are largely responsible for the rigidity of the plant structure. These fibres are, however, held in position in the plant by a "cement" consisting of such substances as lignins, pentosans, pectins, starches, and sugars; these rank as undesirable constituents from the paper-maker's point of view. The principal object of the pulping process is, in fact, to remove them as completely as possible (together with any other objectionable substances, such as waxes, resins, and ordinary "dirt"), and so to make the desired cellulose available. The nature and amounts of these constituents present in different plant substances varies appreciably, and some typical examples are shown in Table I, from which incidentally, it will be noted that while cotton (e.g., in rag), has a particularly high cellulose content, woods are appreciably richer than straw in this respect.

TABLE I

Material	*Cellulose*	*Lignins*	*Pectins*
COTTON	92–97	4	2%
STRAWS			
Barley	48·6	16·4	31·9%
Oat	43·8	18·5	22·8%
Rye	36·3	11·3	20·4%
Wheat	56·7	16·6	28·4%
WOODS			
Aspen	62·1	26·5	17·6%
Spruce	60·9	30·2	12·6%

The principle behind the method of purification used is to dissolve, or render soluble by chemical action, as much as possible of the plant constituents, except of course the cellulose. A certain amount of attack on the latter is, however, unavoidable; so much so that although the cellulose content of straw is from 36% to 57% (Table I), the actual amount of pulp recovered in practice (allowance being made for mechanical as well as chemical losses) is only 30% to 33% of the weight of straw taken.

The procedure adopted may conveniently be divided into stages, as follows:

(1) *Preparatory.*—The bales of straw are undone, and passed continuously through a chopping machine, which cuts it into lengths of about 4 to 6 inches. It is then "dusted" by passage through a device which draws away the dust in a current of air, while many of the small or heavy particles (such as pieces of baling wire, knots, ears, rootlets, etc.), are separated on sieve-screens. Incidentally, a large proportion of this waste is a welcome addition to the poultry-food ration.

(2) *Digestion.*—The next stage is the primary chemical treatment, and this is carried out by boiling the straw with a solution of caustic soda of such a strength that for every 1000 lb. of straw used, 200 to 250 lb. of this alkali are present. This operation requires 4 to 6 hrs. at a pressure of 60 to 80 lb. per sq. in., but actually the straw is usually in the digesting vessel for more than 12 hrs.; the remainder of the time is accounted for by the operations of raising

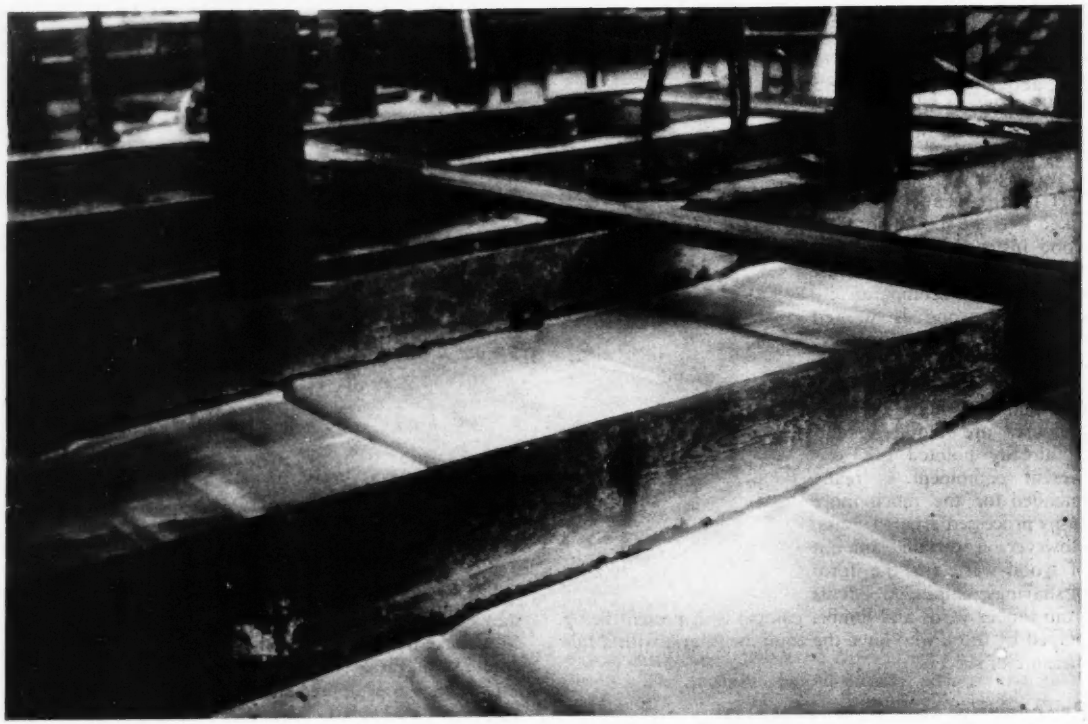


FIG. 5.—A trap for removing heavy particles from bleached pulps.

pressure, cooling off, washing, and emptying. Incidentally, the pressures mentioned above correspond with a temperatures-range of about 153° to 162°C.

Caustic soda is the "general purpose" reagent for pulping vegetable material, and it is used alone or mixed with a small proportion of sodium sulphide for cooking wood (the soda and kraft processes, respectively). The sulphite process, in which the reagent is calcium bisulphite solution containing an excess of sulphur dioxide, is also used widely for wood, and with very good results, but special plant is required for preparing the liquor, and this is not available here at present; moreover, the sulphite process offers no special advantage for use with straw, because of its lower lignin content as compared with wood (*see* Table I).

If a pulp manufacturer were allowed to select his idea of the best digester for his straw, he would probably ask for a long vertical cylindrical vessel, pivoted at its centre, about which it could rotate; in this way the straw would slide from end to end, and mix thoroughly with the caustic liquor. As it is he has to be content with the type of digester he has already chosen for esparto. He has, therefore, a vessel of the right shape, but it does not rotate, and for his mixing he must rely on the force of the steam as he blows it in (the "vomiting" process); or he must draw the liquor out of the digester from a point half-way down, and force it in again at the top and bottom. On the other hand, if he has to use a rag-boiler, this will mean another compromise, though of a different type, because although his boiler rotates, it is spherical instead of being cylindrical (Fig. 1). The greatest disadvantages of a rag boiler, however, may be the difficulty of removing the straw afterwards, and the fact that owing to its relatively small capacity, it is not possible to process very much straw at one time. For comparison, rag-boilers usually hold up to 2 tons of material, whilst esparto digesters hold from 3 to 7 tons.

The hot caustic liquor is added to the digester at the same time as the chopped straw, so that the latter receives a certain amount of pre-digestion. The top lid is then bolted down, the mixing pumps are started, and the pressure is raised. At this stage it is necessary to blow off some of the steam in the space above the liquor in the digester so as to remove any residual air, which will otherwise lower the temperature. At the end of the appointed time the digester is "relieved" by blowing off the steam into a device which enables its heat to be utilized to advantage, and the digester is then opened. Then follows what for straw is one of the key operations, namely, washing.

(3) *Washing*.—It is obvious that once the impurities in the straw have been rendered soluble, it is essential that they should be removed as completely as possible; hence the importance of washing. Unfortunately, straw-pulp is not washed easily. When it is cooked it develops a somewhat gelatinous character, and although the simile is very exaggerated the problem resembles that of washing a jelly; it will not drain.

The probable reason for this is to be found by comparing the microscopical structure of straw with that of a fibre, such as wood or esparto, which are much less troublesome, and photomicrographs of these three fibres are shown in Figs. 2, 3 and 4, respectively. This comparison shows that in addition to the fibres (the long slender, ribbon-shaped structures) straw contains a number of smaller elongated or "sausage-shaped" structures (parenchyma cells), which are absent from wood or esparto. This description is not greatly exaggerated, because they are in effect analogous to sausages, whose "filling", so to speak, has been dissolved out by the digestion process, and consequently the empty skins lay across the interstices between the fibres and effectively hinder washing and drainage.

Washing is usually carried qut by filling the digester at the top with water or weak caustic liquor, and removing it at the bottom. The resulting wash liquor contains too much caustic soda to justify rejecting it, on the grounds both of economy and of injury to life in the stream which would have to receive it. It is therefore evaporated to a syrup and burned, and a solution of the residual ash (mainly sodium carbonate) is boiled with lime so as to regenerate the caustic soda. Two or more additional washes are then applied, and when the resulting drainings are too dilute to be worth recovery, they are stored for use as the first or second wash of a subsequent digestion; in this way they are strengthened up to a fit condition for recovery. When as much as possible of the alkali has been removed, the pulp is dropped into a large chest beneath the digester, by the simple operation of opening a large valve at the base.

(4) *Bleaching*.—The pulp is still dark in colour, and since the alkali has done all that it can in the way of purification without degrading the cellulose, a rather different method must be adopted as the next stage. The pulp is accordingly transferred to a "potcher", an oval-shaped tub with a central wall which does not quite reach to the "points" of the oval. On one side of this wall is a rotating paddle-roll carrying metal blades, and this both circulates the straw around the central wall, and breaks it up into a true fibrous pulp. The straw passes under the roll, and between it and a set of fixed metal blades in the floor of the potcher, which is sloped to facilitate circulation. On the other side of the central wall is a rotating drum covered with wire gauze, and so arranged that the water (but not the pulp) can flow through the holes and so be removed. If at the same time fresh water is added on the other side of the potcher, the pulp can be given a final wash preparatory to bleaching.

Bleaching is relatively a simple process. A solution of bleaching powder equivalent to about 4% of chlorine on the weight of original straw is added to the potcher and mixed well with the pulp, and the resulting mixture is pumped into a number of tall towers, each holding the equivalent of 1 or 2 tons of dry pulp. Here it is left until tests show that bleaching is complete. As in all the other stages of manufacture laboratory control is important, because too much bleaching agent or too prolonged a bleaching period will result in attack on the cellulose. Uniformity of bleaching is sometimes ensured by pumping the pulp continuously from one tower to another along a series of towers. The bleached pulp then receives a final wash, either by one of the methods already outlined, or in more modern mills, on a rotary vacuum filter. In this latter apparatus the pulp (containing, say, 97% of water), is fed on the surface of a rotating drum covered with wire gauze, suction being applied from inside the drum. The result is that the expended bleaching liquor and the harmful chlorides it contains are extracted from the pulp, which may be still further purified by spraying it with water as it lies in a cake on the drum. For reasons already indicated, straw does not lend itself well to washing in this way, as the empty parenchymal cells lay across the holes in the wire; in illustration of this it may be mentioned that whilst esparto can be removed from such a washing-filter with a water content of only 70% to 75%, the filtered straw often contains 90% of water.

(5) *Mechanical Purification*.—The epilogue to this series of purification processes is mechanical instead of chemical in nature, since its object is to remove physical rather than chemical impurities; undigested pieces of straw, weeds, sand, ears of grain, etc., fall into this category. In the first stage of mechanical purification very dilute pulp runs over trays, on the floors of which are slanting wooden baffles which trap heavy particles as they tend to sink (Fig. 5). The pulp then flows through metal screens containing fine narrow slits, which keep back anything having dimensions appreciably larger than those of a straw fibre (e.g., undisintegrated fibre lumps); then as a final touch an apparatus which subjects the pulp to a centrifugal force, and thus throws out the heavier particles, may be used. It will be noted that none of these processes effects any appreciable removal of the objectionable parenchymal cells which are so characteristic of straw; indeed, to remove them all (were this possible) would involve a sacrifice of some 30% of the possible yield.

The straw pulp is now at last ready to be made into paper; it has reached the status of "half-stuff". Although no special features or processes are introduced into the normal paper-making process when straw is being used, there are certain important points of difference between it and the peace-time paper-making fibres, and most of these may be attributed once again to the parenchymal cells. Thus, as these are further separated and broken up in the beating stage, their power to hinder drainage becomes still further in evidence, and the pulp therefore loses its water slowly on the wire of the paper machine; this results in slow drying, and consequently slow running, and sometimes a cockled final sheet. On the other hand, these same cells lodge in and fill up the interstices between the fibres, and so produce a sheet which is close in texture, resistant to ink and relatively strong. For obvious reasons, therefore it is not usual to make paper of straw fibre alone, but to blend with it pulps which have compensating characteristics. In peace-time the selection of such pulps would present no difficulty, but nowadays whatever portion of the wood-pulp ration is available, or else rags, has to be used.

In spite of all these handicaps however, it must be conceded that many of the papers containing straw are excellent in quality, though possibly rather different in character from their peace-time counterparts, having a harder handle and more "rattle". Possibly they are also less clean, sometimes containing narrow, light-yellow translucent specks (especially if the paper has been

calendered to a smooth finish), but these defects often arise from weed or undigested straw, and are frequently a demonstration of the limitations of esparto-digesting plant when applied to straw.

Has Straw Come to Stay?

So much for the past and present of straw; what of the future? Has straw come to stay? Prophecy is never easy, and it is a particularly thankless task nowadays; but there is no harm in drawing up a balance-sheet of straw in comparison with its foremost rival, wood-pulp. On the credit side for straw we have, firstly, the fact that it is a home-produced raw material, and given a suitable agricultural policy it should become available after the war at a price which should satisfy both farmer and paper-makers; this has been possible, at any rate in Holland. Secondly, under peace-time conditions and as a result of fundamental research work on the subject (and this incidentally has never been applied to straw as intensively as it has to wood-pulp), considerable improvement might well be introduced into both the harvesting and the pulping processes, resulting possibly in better qualities and yields. Thirdly, a certain amount of digestion and recovery equipment is available in this country, and if no esparto is to be digested in it, it is not good economics to leave it idle. This perhaps is a point of less significance, because it is influenced by the price of wood-pulp, which as pre-war experience has shown can be cut very low, despite high delivery charges; moreover, esparto may well return again, and many makers of pulp and users of paper will welcome it. These are factors which will be determined largely by post-war international trade agreements, and consequently, they admit at present only of sheer speculation.

On the debit side, however, we have the relatively low production of straw due to low yields; slow throughput (because of the long digestion- and washing-times); small throughput per digester (because of the bulky character of the raw straw); and slow-running on the machine. Some of these drawbacks are particularly noticeable when comparison is made with esparto. Costs of materials are high also, because more steam and caustic soda are needed for digestion; the proportion of alkali obtained for re-use by means of the recovery process, too, is much less than for either wood or esparto, because of the washing difficulties. The differences in the quality of the paper may justifiably be assumed to balance, because although on the whole the bad points probably exceed the good, they may be offset, and probably even turned to good account by blending with pulps of opposite types. In this connexion, one advantage possessed by wood-pulp and not as yet shared by straw (or esparto) is that it can be produced in many different grades, and therefore, it can be used for most types of paper.

On the whole, therefore, the balance for and against the use of straw in the future is about equally weighted. On the adverse side we have a number of minor disadvantages, and on the other a smaller number of more weighty advantages. Possibly the price factor will decide in the long run, in which case we may find that in the event of a future war, history will repeat itself a third time. On the other hand, corporate research on an appropriate scale has made wood-pulp manufacture an important national industry of Scandinavia, Canada and the United States, and there seems no reason why it should not do the same for straw in this country. British straw papers then might well occupy a position of merit alongside British esparto papers (should these become available again) while blends of both together and with other fibres should fill many paper requirements both at home and abroad.

A Farmer on Research

A FARMER's views on agricultural research were given by Mr. Anthony Hurd in a paper read before the Royal Society of Arts on 13 January. Mr. Lloyd V. Steere, Agricultural Attaché to the American Embassy, presided. Mr. Hurd explained the mistrust of some farmers towards artificial fertilizers as being due partly to ignorance of the science of plant nutrition, and partly to the extravagant claims made for "artificials" by commercial firms when they started to exploit the work of research chemists. The farmer was chary of short cuts to fortune. It was doubtful whether in ordinary times one in five of our 300,000 farmers was in regular touch with the county agricultural organizers or the advisory staffs. The scientist in the laboratory had been wrapped in mystery and the ordinary farmer felt that research and science were beyond his ken, because the system of agricultural education has been woefully inadequate and hardly touched the average farmer. The findings of research did in time, of course, filter through to the farmer, but it was a terribly slow process. The complicated set-up of agricultural research in this country was partly to blame as it led to delays and overlapping. He thought it would be plainer sailing for all concerned if one body controlled the organization and finance of agricultural research. The recently formed Agricultural Improvement Council should help to tie up research more closely with the farmer. To-day wholesale methods of modern publicity were being used to spread agricultural intelligence among farmers, as for instance the Ministry of Agriculture service of free leaflets, of which 2,700,000 were sent to farmers in 1942. Radio was another good method of bringing new techniques to the attention of the farmer, and after the war, when there would be room on the air, the B.B.C. could usefully expand this service. The Minister of Agriculture had asked for another 15 to 20 per cent increase in farm output in 1943; given a favourable season this could be attained if the lessons of research could be applied still more effectively and more widely, which meant raising the general level of farming to the standard of the best farmers. "We need all that scientific research can give us if we are to establish British agriculture as a vigorous and progressive industry ranking high in public estimation," concluded Mr. Hurd.

Psychology and Persuasion

ALEC BROWN

ADVERTISING is not exactly what advertisers pretend it is, or what the word "advertising" properly means. The advertiser does not merely inform us of things we might like to know about, leaving it to our free judgment and choice, to make use of his information as we please. In both advertising and that form of advertising known as propaganda, the advertiser, or propagandist, definitely wishes not merely to inform us, but also, more important still, to influence our choice and our action. Here is a simple illustration of how advertising works:

Some years ago a certain typewriter company was unsatisfied with its sales in a country which was very literate, and therefore might be expected to absorb a large number of typewriters. Fairly large total numbers of typewriting machines were indeed sold, but the proportion sold by the manufacturer in question was not large enough. How were people to be persuaded both to buy more typewriters altogether and also to buy more of that particular make?

The firm in question employed an American "psychology expert" to solve its difficulty. Soon afterwards, the main show windows of this typewriter company went gay. On suitably draped tables rested dainty portable machines. There was a blue machine, a green machine and a red machine; there were no black machines.

The result was astonishing, also interesting—for two reasons. Sales did leap up. A steady flow of enquiries about the coloured machines began. People were attracted to them like bees to flowers. Of course, some who enquired already did wish to buy a typewriter, and by the colour device were merely diverted to buying a certain make of machine, but investigation soon showed that the *total* number of typewriters of *all* makes being bought in this particular country increased. Clearly a number of people, who would not otherwise at that time have bought any typewriter, now felt moved to do so. In other words, this "advertising" device had not merely informed the general public of the firm's machines by the use of colour—quite unessential to a typewriter—it had also developed a new desire in many people.

But this is not the whole story. The stimulus to buy typewriters was created by showing coloured typewriters, *but it was not coloured machines that were bought.* All over the country customers entered shops and fondly handled coloured typwriters; but they then proceeded to buy the ordinary black machines which before they had scorned. They quite frankly found the black machines more "practical".

This is a crude example of how advertising can work. By working on certain features of the average man's make-up, it is possible to influence his decisions. It is the art of doing this, that constitutes the arsenal of the propagandist or advertiser, whether he is conscious or not of the way his weapons work.

Undoubtedly—as is revealed by even a cursory examination of current advertisements in newspaper, magazine, bus, underground or cinema—the devices used are generally limited to a very few tricks. The colour bait, though fundamentally simple, is relatively recondite. At the bottom of much advertisement lies mere flattery of the victim. It is suggested to him that he is like his own ideal of himself, i.e., cleverer, stronger, more handsome, taller, tougher-bearded, softer-skinned, more practical, etc., than he really is. Whether he is handsome or not matters little in deciding what kind of shaving cream to use, just as colour really matters little when one intends to buy a black typewriter. But even flattery may be accomplished very subtly.

Recently the London and Counties Coke Association produced a handbook on *Combine Harvesters and Grain Driers.* For a farmer it is a very interesting little book, even for a farmer who is already using combines and is familiar with them, for it describes all kinds of combines in excellent detail, with fine illustrations, and much information about the cost of running them, not only per acre, but even per bushel of wheat or other crop. It then proceeds to describe grain driers, which are of supreme interest to British farmers at the present juncture. This occupies 57 pages of the book, leaving 4 pages at the end to describe coke-burning plants which can be used in conjunction with driers.

The flattery here is so subtle, and so thorough, as to amount to beautiful civilized conduct. At the basis of civilized conduct lies mutual advantage, though we should none of us like to admit this without some qualification. Qualification there is, for it is our nature to find pleasure in the graces and ceremonies with which we quite rightly cloak our exchanges of mutual advantage. There can be too much elegant ceremony, so much that it stifles the mutual exchange of which it should be no more than a beautiful outcropping—and there can be too little. We do not like the boor, any more than we like the over-suave, over-courteous person; our common-sense with its appreciation of balance constantly brings us back to a reasonable measure of ceremony.

The London and Counties Coke Association is to be congratulated, for it does not flatter the farmer by merely pretending to take an interest in him. It does take a real interest. The result is that at the price of half-a-crown, for which it is sold, the Association's booklet is cheap information. There is everything right about this kind of flattery, better known as "taking an interest in the other man". The farmer who reads the booklet, without doubt, generally will feel that the Association, though a business concern, really consists of rather nice people who are aware of his existence and his needs.

Here too "psychology" has, as understood in common parlance, been employed to obtain a certain result. The

advertiser wishing to exercise some influence on the ideas, the actions, the choice of Mr. Smith, Mr. Jones or Mr. Robinson, to do so effectively takes account of the workings of the average man's mind.

This is the basic situation which it is difficult to ignore. Psychology in advertising merely means utilization of knowledge of the common movements of the average mind *of those addressed in any particular campaign*. There is no such thing as a "psychology of advertising", and so far in this essay the word has been used in that sense, merely because so many people do use it like that. There is merely psychology—or the science of the mind; and advertising can work most efficiently by conscious exploitation of fundamental mental reactions which are common to most people.

Psychology, or the science of the mind, is a horrible and ancient battle-field, because although the investigator is dealing with something outside himself, i.e. another person's mind, he can never get quite inside that mind, to measure and trace its workings, as one can measure and trace the behaviour of falling bodies or of chemicals in process of combining to make a new chemical. Added to that is the difficulty that he is observing one mind with the aid of another one, presumably somewhat similar in basic construction, yet puzzlingly different in its interests and its bias, i.e. with his own mind. And because of this, he is prone to explain those things in the other mind which seem to defy examination, in terms of his own mind. But where desires, likes and dislikes are concerned, it is hard to say if he can observe his own mind at all.

This makes psychology seem pretty hopeless as a science. It can never be exact, or complete. Yet common sense tells us that many observations regarding the human mind are quite as precise and exact as those concerning the coefficient of expansion of metals, or the behaviour of substances under varying conditions of pressure and temperature. For example, common sense might have told us that people are more attracted by coloured typewriters than by black ones. We scarcely needed the sales returns of the Remington Company in France to convince us of that. But we were not so likely to know by common sense that colouring some typewriters would make people buy more black ones. We do know of people of astounding development of insight (or intense common sense), who seem to cut through all cumbersome investigation of the conduct of others, and by a lightning-flash of weighing-up, perceive the line of action the other person will take under given change of circumstances. But this is rare and can scarcely be calculated on.

The existence of common sense need not surprise us, particularly if we remember that we do not all work in the same way. Even without tuition, young Mr. Jones will put his fingers somewhere into the awkward dark crannies with which modern British motor-car design has furnished the world, and without ever seeing it properly, adjust a certain screw—while Robinson cannot do it, even after training. In the one person, from birth, an innate disposition has been intensively, inevitably, developed—the tactile senses, the observation of movement of parts of instruments simple and complex—and the result is an early skill which seems miraculous. Perhaps Robinson can handle musical sounds with the same "innate" ability that Jones handles screws. In either case there is a specialized ability to perform certain operations—common sense is merely a broader and more general application of a comparable ability to understand human action.

But apart from this common sense understanding of others, or what we might term natural psychological understanding, which is built on observation of others from infancy upwards, by persons peculiarly adapted from birth to do this, and appraise the motives of others' actions, there is always with us another kind of psychology. This is akin to the Heath Robinson-ish machines which some unfortunate would-be inventors constantly invent, or to some of the abstract, *thought-out*, but not experienced or felt, music, which every now and then is inflicted on the world. It is the result of introspection, not of observation of the living world about us. The mind indulging in this, though provided with an innate disposition to dabble with the nature of the mind, does so without any reference to what other minds are occupied with.

Throughout human history, psychology (or its equivalent) has swayed violently between these two extremes. One extreme has in truth nothing whatever to do with understanding the human mind; it is concerned merely with fantasies about minds. But since the object of psychology is the furtherance of our relationships with other people (since we are primarily social animals), such fantastic imaginings are clearly of little use. The other extreme has often produced remarkable results.

But between this common sense, however supreme, and a science, there is a great gulf. It is only in recent times that a true co-ordination of "common sense" observation, and attempt to systematize it, has begun to appear. There are two reasons for this, and they are connected. Firstly, it is only in the past two or three centuries that scientific method as such has been evolved. While there was more room in the world for man, and not such pressing need to master the forces of nature and control them for his needs, a general system of co-ordinating natural facts was unnecessary; "science" need not be evolved.

Secondly, it is only much more recently that there has developed more specially an urgent need to build up a science of human thought and human conduct. For this pressing need, we had to wait till the world had filled up still further, and there was even less room for uncoordinated human action. Just as there was sufficient demand for greater mastery over nature, the mental machinery for that mastery was evolved, so to-day the need for controlling the desires and actions of vast masses of human beings is producing a science of understanding human motives and desires. Psychology is not merely a gossipy description of what takes place inside a man's mind. It is a weapon for assisting mankind in working together in co-ordinated effort.

While haphazard *ad hoc* methods of human organization produced sufficiently good results, psychology was little needed. Now that haphazard methods no longer suffice, it *is* needed. The utilization of this instrument for advertising is merely a narrow, though exemplary part, of its utilization for the grander purpose of human government, for greater human happiness.

Perhaps this explanation should be amplified. It is a matter of management of each other. The owner of a factory in 1743 may have employed sixty men. It was not difficult for him, by his common sense, to understand their

likes and dislikes, in other words their psychology, and make the most of their labour. In 1743 the organization of the work of a factory was a comparatively simple job, which an average single mind could encompass. Even if half of the sixty men proved not to fit in with the factory-owner's scheme of work, there were other men available. The supply of free labour was just beginning. The whole of society was not occupied, as it is to-day, under the totalitarian conditions of this war, or the peace which is to follow the war.

Our world to-day is complex and fully engaged. We cannot afford the waste of energy involved by wholesale shifting of unsuitable (or temporarily unsuitable) employees from one form of work to another. Merely to keep our world going, with a maximum of harmony and satisfaction to all, it is advisable to have populations very steady. But above all, the numbers involved are far too vast for individuals to manage them. It has become not merely useful, but essential to understand how men's minds work —so as to know how to guide them to fit in where they are.

It is this general condition of modern society, which first began to show with the development of monopolistic forms of industry in Great Britain about sixty years ago, that provided the basis for modern psychology as a science. Psychology may be concerned with examination of the individual mind, for the sake of the individual mind, and most psychologists may be prepared to reject very bitterly any social implication of their work. Yet the fact remains that the sealing up of ever more cracks and spaces in the social fabric has impelled us, *as individuals*, to know more of each other, largely because we can no longer, as individuals in modern society, get away from each other and has brought us to the science of psychology.

The situation is quite the same as with the other sciences. The Newtons and the Faradays did not work because they consciously thought of social needs. Yet the needs of his world for engineering on a more social scale undoubtedly conditioned Newton's work in mechanics and ballistics, and there could have been no Faraday if modern power machinery had not become necessary to society.

Yet the science of psychology is still young, and by its very nature, above all other sciences (except perhaps medicine), it is a difficult science because of the identity between the thing observed and the thing observing it. Partly for these reasons, there are to-day various schools even violently opposed to each other, and one school, that of Pavlov and Behterev in the U.S.S.R., which though it is concerned with the same subject, would even deny itself the term psychology. The probability is that between all of these schools of psychology, the Freudian with offshoots, the Behaviourist, the Gestalt school of Kaffka and the Physiologists, there is a least common multiple of guidance in our understanding of the human mind. This essay makes no pretence to provide the psychological synthesis which some day will be inevitable. Its only contribution thereto will be in so far as psychology in propaganda or advertising is concerned.

The schools of modern psychology mentioned above are not the only schools, but they certainly seem to be the principal schools which lay some claim to providing a general explanation of the mind. One exception, however, should be rigorously made, since the Freudian school makes no claim to be more than a general method of healing mental disorder, by eradicating basic hurts, which have occurred to the tender infant consciousness, and made the whole structure of the developed adult mind instable, and thus incapable of dealing with everyday social life. Yet, in order to do this, Freud and his followers, including those who have developed other psychologies of what might be called the personality, have been obliged to elaborate some general system of how the mind works and how it is built up.

Nor are these schools all related to each other, according to some pattern, or connexion with the mind. The Behaviourists are an American school, which endeavours to describe the mind purely in terms of objective observation, that is to say, potentially by mechanical observation. It is ultra-scientific. It limits itself to verifiable "objective" observation, that is to say, to phenomena of the mind observed which can be measured by instruments. The notion behind this method is that only instruments can observe objectively. Yet it does remain a notorious fact, not merely an illusion, that quite apart from "objective" observation of this nature, individuals can and do arrive at valid assessments of the mental processes of others.

The Pavlov school is a Russian counterpart to the Behaviourist school. It also bases itself purely on observation and it is also special, in confining itself to observation of physical reaction, without any particular specification of the mind. Since this school is a favourite adopted child of Russian Marxism, this is a little surprising. It is a fundamental tenet of Marxism, that phenomena (or the causes underlying them) can fuse, or synthesize, into a higher whole. It is difficult, except for political reasons, to see why there should, in the U.S.S.R., be such determination to deny that very obvious *synthesis of neural reactions*, the human mind, by reducing it to a mere aggregate of conditioned reflexes.

Thus, despite the fundamental differences, there is a great similarity between the Behaviourists and the Physiologists. This may have its origin in certain similarities (despite, once again, the great differences) between material expansion in the U.S.A., and the U.S.S.R. Such similarity is admitted by Russians, and one finds national, politically canonized poets, such as Bezymensky, singing praise of the collaboration of Yankee engineers and Russian workers in U.S.S.R. industrial construction.

Between both schools there is this in common: each, rather mechanically, regards man's mind (in so far as each admits it) as a vast complex addition of one conditioned reflex on another. By a conditioned reflex is meant any response made to an external stimulus, which has become automatic (not requiring the intervention of thought), because it has been repeated sufficiently often to become part of our make-up. Watson, the Behaviourist, even makes speech and *also* thought, simply a product of movements of the larynx. By instruments he shows that even when thinking, movements of the larynx corresponding to the thought words, can be recorded. His conclusion is that these laryngeal movements, added up, constitute thought, and thought is merely a complex, automatic, physical reaction.

Pavlov's ideas are represented by the notorious set of experiments with dogs. Feed the dog when a bell rings for some days, then ring the bell without food, and "in expectation", as we should say, the dog's salivary glands

act. Both Watson and Pavlov—each in his way—would say that when the child first sees red and hears somebody making the sounds "*red*" or "*rouge*" or "*krasny*", etc., it comes automatically to associate the redness with the word "*red*", or "*rouge*" or "*krasny*", etc., and imitates this. Afterwards, even the thought "redness" makes the larynx move as if saying "red".

Now, without going here into the question, whether this mechanical additive view of the human mind, or some other, creative, synthesizing, view is correct, there certainly is truth in the particular individual observation. The bearing of this on our subject will be clear very shortly. It remains first to glance at the other two general approaches to the mind.

Freud's name is generally associated with a peculiar emphasis on sex. Properly it is a curative process of analysis of one person by another, during which the dark recesses of the patient's mind, where at an early stage the foundation got twisted, are explored. The schools of Jung and Adler are offshoots from the Freudian. In common they have the concept of part of our "mental" processes being conscious, part unconscious, and all look on the mind as an entity in itself. They differ regarding the factors which go to make a mind on which emphasis is laid.

They differ also, in the writer's opinion, in that both Jung and Adler introduce much mysticism into their view. They seem to be less objective, less scientific than Freud. In so far as the habits of thought of his surroundings (Vienna of the pre-Nazi days) allowed him, Freud did refrain from inventing any concepts where there was not very strong reason for postulating a hypothesis. Freud's system is essentially a clinical method. Yet out of it there does emerge a co-ordinated view of the human mind. The strength of Freud's work lies in his elucidation, in relation to the fundamentals of birth and early feeding, of the development of sex and feeding instincts, which seem to be largely a least common multiple of behaviour, valid for all human beings of whatever country.

This, in a larger synthesis, does not seem necessarily to be in conflict with the ultra-scientific schools. It is surely obvious that the first reactions of a new-born child (or even an unborn child) to outward stimuli and the way it is able, or unable, to build up satisfactory reactions, must play a profound part in creating its mind, or the general way in which it deals with the world about it.

Beyond that—partly a result of the influence of his surroundings and the complex layers of the modern capitalist state—Freud elaborated a complex system of conflicting forces which seems to be in the mind. Into these it is not necessary to go here. It is sufficient to adopt a matter-of-fact view of the mind, which in essence is not in conflict with Freud's. It is this. Stresses are set up within us by conflict between our impulses and the repressing, inhibiting forces of the group into which we are born, and with which we have to live. To take a very simple example, the initial impulse for a child to feed at it's mother's breast must eventually be checked. Between the basic impulse, and the checking, there results a state of strain. This finds its resolution in various ways. It is most satisfactory if the basic desire, or impulse, is harnessed to some other act. This most easily takes place, when the other act which is to be of use in adult life, is also of a similarly pleasing nature. Thus by satisfactory weaning, the impulse can be gradually trained to find outlet in other forms of feeding. If it is not, a more or less persistent infantile attitude towards food, or too great a conflict caused by overcoming the infantile attitude, makes a person abnormal.

Here is the very point which interests us in regard to our present subject. Throughout life, even if the basic response is harnessed to other acts, the basic impulse is always lurking in us. If not actively seeking a resolution, nearer to the original act, at least enjoying such a resolution, or enjoying being reminded of it. This seems to be why we often have recourse to representations of the originally desired object, as in art, or find satisfaction in forms which are reminiscent thereof, as, in ancient Egyptian religious symbolism—an early form of advertisement—the representation of the sun rising behind two mountains.

Here we can see a form of device which the advertiser may use unconsciously or consciously—he may influence his victim, not by direct flattery, but by this other form of flattery, which will consist in providing him with fundamentally pleasing forms, which affect deep concealed impulses. If in these he frames the far less pleasing, less enticing information which he wishes to impart, that information stands a far greater chance of being assimilated than if presented devoid of other enticement. Any close observation of successful pictorial advertisement provides many examples of this.

Further, in his work, Freud elucidated how we live by situations, by formalized groupings of people and acts, and in his theory we use some situations and acts, and objects, as symbolic forms by which to indulge, as it were, in conversation with ourselves, about what we desire, or what troubles us, while at the same time playing a game with ourselves, deceiving ourselves, and making it easier for ourselves by concealing the real material of our thoughts —just as the Egyptians used the symbol referred to. The fruitfulness of material here for a really able advertiser, is obvious.

Yet there are objects, or qualities of objects, which are pleasing to us entirely outside this Freudian view. There are fundamental physiological reactions, which seem to have their basis in the very material of which we are made. Such are colours, used by the typewriter company, to please and beguile its customers. There we come to the most primitive material of all. But it is the psychology of Kaffka which seems to aid us to understand it and also, for our purpose here at least, to provide some measure of co-ordinating all the schools.

Kaffka, a German psychologist, evolved a description of how the mind works in everyday life which he called *Gestalt-psychologie*. This has been rendered into English as the "psychology of conditioned wholes". Kaffka does not pretend, in his work, to analyse the very beginnings of the human mind. He is content to deal with how the mind reacts to the actual, real world it lives and works in. For that reason his psychology is for normal people the most useful of all. It also provides a means of co-ordinating and utilizing other psychologies; at least, as far as their application in advertising is concerned.

The meaning of conditioned wholes is easily illustrated by words. If I ask the printer to print a f w w rds without s m f th l ters, I am s re y u w l have l ttl dif cul y in reading it. One or two words may puzzle

you for a second—that is all. Similarly, seeing one light set above two others, equidistant from each, and about as far from them as they are from each other, we tend to see a triangle. The reason for this, Kaffka points out, is that the eye does not, in reading, usually examine all the letters, but rather the total outline of the word, and particularly if a gap equal to the space which the missing letters would have occupied, we very easily fill them in automatically (or similarly, we supply the lines required for a triangle). Our eye is conditioned, or trained, to a whole, and just as we recognize a drawing which gives only the outline, so we recognize a word or an object, rather than unsynthesized letters or points. Indeed, our minds rebel against seeing disorganized, unsynthesized things.

To this observation there is an important corollary. We become so accustomed to certain shapes, that when we see objects which form but part of them, we tend to supply the whole outline. This explains how it is that the two hills of the Egyptian symbol can suggest breasts. But it does more than that. It provides us with an understanding of why shapes of objects we use change so slowly. The motor-car is still usually provided with an engine in front, because there were so long horses in front of the carriage, which they drew—although there is no rational purpose in putting the engine there, especially if the car is to be driven through its rear wheels. It also provides us with a mode of approach to all other associations and "conditioned reflexes". It provides us with a guide anda warning, if we are trying to advertise, or otherwise educate or influence others.

Namely, not only must we beware of all their deeper impulses and have some notion of the symbolic forms in which these are commonly cloaked, in deep thoughts, in dreams, and in folk myths (where Freud can help), not only must we bear in mind conditioned reflexes which are entirely independent of the life impulses with which Freud deals, and which are probably purely physiological, in a much simpler, though less vital way (as with the liking for colour)—but we must also bear in mind the essentially static, conservative nature of the human mind, and that particularly when grown up, when adult and hardened, it is used to a large number of total situations. It is conditioned, not solely for the individual ringing of a bell, but for this synthesized with a large number of other circumstances. The more complete the total situation connected with the bell ringing, the more whole will the reaction to it be, whether pleasurable or pleasing. Therefore, to obtain a maximum response to propaganda, it is not sufficient to titillate the recipient with mere colours, or with pleasing situations, unless we take care to include these in a whole, a total, a Gestalt, as Kaffka would call it, which is familiar to the recipient.

The Night Sky in March

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—New moon occurs on March 6d. 10h. 34m. U.T. and full moon on March 21d. 22h. 08m. The following conjunctions take place:

March

3d. 03h.	Mars in conjunction with moon,	Mars		3°S.
4d. 19h.	Mercury	,,	Mercury	2°S.
8d. 08h.	Venus	,,	Venus	3°N.
12d. 11h.	Saturn	,,	Saturn	4°N.
15d. 18h.	Jupiter	,,	Jupiter	4°N.
31d. 22h.	Mars	,,	Mars	2°S.

Occultations.—The following occultations of stars brighter than magnitude 6 occur, the times referring to Greenwich:

March 12d.	16h. 40·2m.	α Tauri	D
12d.	17h. 51·8 m.	α Tauri	R
17d.	22h. 43·0 m.	0¹Cancri	D
17d.	23h. 03·0m.	0²Cancri	D

(D and R means disappearance and reappearance, respectively.)

The Planets.—Mercury is a morning star at the beginning of the month and Venus is an evening star. Mars is a morning star, but is too low for observers in the northern hemisphere. Jupiter is visible for most of the night and Saturn sets about midnight.

Comets.—Comets Reinmuth and Whipple are well placed for observation during the month; the latter will probably be a naked-eye object or at least can be seen with field-glasses. An ephemeris follows:

COMET WHIPPLE

Date 1943	*R.A.*	*Dec.*	ρ	*r*
March 1·0	12h. 11·2m.	+55·2°	0·532	1·392
5	12h. 19·1m.	54·8°	0·552	1·407
9	12h. 25·3m.	54·1°	0·574	1·424
13	12h. 31·2m.	53·2°	0·597	1·443

Comet Reinmuth is at distances $\rho = 1{\cdot}194$ and $r = 2{\cdot}176$ (referring to the distances from the earth and sun respectively) in the middle of the month, and will not be a very conspicuous object. Its position on March 15 is, R.A. 12h. 08m., Dec. + 12·3°.

Spring Equinox commences on March 21d. 12h.

Far and Near

Science and the Citizen

ON Saturday and Sunday, 20 and 21 March, the British Association is to hold a Conference on "Science and the Citizen" at the Royal Institution, London.

There will be four sessions, of which the first will be concerned with the methods of the famous expositors of science: Sir Henry Dale, President of the Royal Society, will take the chair, and among the speakers will be Sir A. V. Hill (speaking on T. H. Huxley), Sir James Jeans, Professor Lancelot Hogben, and Sir Lawrence Bragg.

In the afternoon the presentation of science by radio and film will be discussed. Sir E. V. Appleton, the famous radio-physicist, will speak as well as Miss Mary Field, well-known for her nature films, and Mr. Ivan Smith of the B.B.C.

Professor Harlow Shapley, the distinguished American astronomer, and a pioneer of the exposition of science by Press and radio, has been invited to speak in this session. The evening will be occupied with a showing of scientific films.

Next morning, "Science as a Humanity" will come up for discussion, with Professor John L. Myres in the chair. A list of well-known speakers includes Professor Farrington on "Science in the Ancient World," Professor R. V. Southwell, the distinguished engineer, Mr. W. E. Williams of the Army Bureau of Current Affairs, and Dr. C. H. Waddington.

The final session on Sunday afternoon will consider "Science and the Press." In the chair will be Sir Richard Gregory, President of the British Association, and editor of *Nature*, and the speakers will include Mr. H. Martin, editor-in-chief of the Press Association, Dr. David S. Evans, advisory editor of *Discovery*, and Mr. J. G. Crowther, science officer of the British Council.

Report on Industrial Research

THE Federation of British Industries has set up a committee under the chairmanship of Sir William Larke, to report on the state and future of industrial research. It will survey present industrial research activities and obtain an assessment of the results already achieved preparatory to making plans so that the scientific ability in British industry, which has been successfully organized in the war effort, shall be harnessed to the work of post-war industrial development and reconstruction.

Formation of Planetary Systems

SINCE the rejection of the Tidal Theory of the origin of the solar system other theories have been advanced, some of which have been shown to present equally serious difficulties. The most recent of these has been developed by Bertrand M. Peek in *The Journal of the British Astronomical Association*, 53, 1, 1942 December. In his *Astronomy and Cosmogony*, p. 346, Sir James Jeans attributes the angular momentum of a nebula to currents of motion in the original medium, and when these currents had developed a rotation of the nebula, this rotation would increase in speed as the nebula contracted, in accordance with the principle of the conservation of angular momentum. Peek applies the same principle to the stars in their early stage of condensation, random currents in the medium which is just about to condense contributing angular momentum to the nascent stars. The angular momentum is not assumed to have affected the main mass of the condensation, being restricted chiefly to the periphery throughout the condensation. As the nebula contracted with increasing angular velocity a time would arrive when material would be ejected from the star in formation and this matter would then pursue its own orbit about its primary. In this way he explains the formation of the planets, and the difficulty of sufficient angular momentum is overcome—a difficulty which has been responsible for the downfall of many other theories. He shows that if the original current had a mass equal to that of all the planets combined and was moving with a velocity of only 2 metres a second, it would have been able to endow the whole of the solar system with its observed angular momentum. This very modest demand for such a small velocity is not likely to be criticized, but there are other parts of the theory which are open to objection—as the author himself admits. The manner in which matter is shed from the rotating mass is not explained though three possibilities are suggested: (1) The matter might go off from the edge of the equatorial plane of the rotating star in a continuous stream; (2) One large mass or ring might become detached which would then break up into smaller masses and form the planets; (3) It might leave the star in a succession of discrete aggregations or rings. Peek does not deal with the abstruse mathematics of this particular part, but it is possible that it may be considered at length later.

During the condensation of the planets a series of similar events may have occurred to produce the satellites, but in this case the magnitude and direction of the current are not fortuitous, as in the case of the original current in the nebula from which the stars evolved. It is shown that the direct rotation of most of the planets and their satellites can be explained by this view, but retrograde satellites and the system of Uranus present a difficulty. Matter left over from the planetary condensations may have been responsible for the short-period comets.

The theory possesses the merits of simplicity, compared with some of the other theories. Many points in it require further investigation, and no doubt this will be undertaken in time.

Hannay's Artificial Diamonds

AT the Mineralogical Society's meeting on 28 January an interesting paper on "An X-ray study of diamonds artificially prepared by J. B. Hannay in 1880" was given by Mr. F. A. Bannister and Dr. K. Lonsdale.

J. B. Hannay claimed to have produced small diamond fragments by heating paraffin, bone-oil and lithium in sealed Lowmoor coiled iron tubes to a red heat. Twelve fragments remain from those tested in 1880 by N. Story-Maskelyne who fully supported Hannay's claim. X-ray examination of this material now preserved in the British Museum identifies eleven of the twelve fragments as diamond. They are transparent, irregular cleavage fragments, averaging $0{\cdot}5+0{\cdot}2+0{\cdot}1$ mm. in size, and some of them give, in addition to the usual diamond pattern, weak X-ray powder lines revealing the presence of impurities. Laue photographs of one of Hannay's diamonds taken with the 5 kw. rotating anode X-ray tube in the Davy Faraday laboratory have shown conclusively that it is of the more rare kind classed by Robertson, Fox and Martin as type II. Such diamonds are unusually transparent in certain regions of the infra-red and ultra-violet, are free from strain, but possess a more mosaic type of crystal structure than ordinary diamond. We believe that J. B. Hannay did indeed make diamonds and that the method he used is capable of giving the transparent type which is apparently rare among natural diamonds, perhaps because the latter are so seldom really pure. However, the difficulties which Hannay encountered, the low percentage of success in his numerous experiments, and the minute amount which even the most successful experiments yielded, show that any hope of making artificial diamonds on a large scale is hardly likely to be realized without considerable patience, perseverance and expense.

Propelling Machinery in Ships

THE fifteenth Thomas Lowe Gray lecture was delivered before members of the Institution of Mechanical Engineers by Mr. C. C. Pounder, M.I.Mech.E., chief technical engineer of Messrs. Harland & Wolff, Ltd., Belfast, on 8 January. The subject of the lecture was "Some Types of Propelling Machinery available to Shipowners".

There are two primordial classes of propulsion machinery at the service of shipowners: Diesel machinery and steam machinery. The former is available in three forms of direct drive, namely: double-acting two-cycle, single-acting two-cycle, and single-acting four-cycle; and in two forms of indirect drive, namely geared Diesel engines and Diesel-electric engines. Steam engines are available in three main forms, namely: geared turbines, turbo-electric engines,

and reciprocating steam engines. The lecturer reviewed the most recent developments in design and practice covering some examples in this broad range. He also dealt with the problem of steam generators.

During the period between the two wars, Mr. Pounder estimated that the improvements in ship propulsion, that is the contribution of the naval architect towards reducing the horse-power needed to propel a ship, can in general terms be said to have been 15 to 20 per cent. In the same period, the engineer's contribution has been the reduction of the specific fuel rate by 50 to 60 per cent for those who have taken full advantage of his efforts. Combined this means that if 20 to 25 years ago the fuel rate for a ship carrying a certain dead weight at a certain speed was 100, to-day that fuel rate could be 33.

What of future trends in the development of propulsion machinery? For Diesel direct-coupled engines Mr. Pounder suggests an increase in mean pressure, a saving in weight by the greater use of fabricated steel and other materials, not excluding plastics; and an increase in power/weight ratio resulting from the two former considerations. In the case of the indirect-coupled unit, rates of revolution will tend to rise, to save space and weight, but restraining influences will be the accompanying problems of noise, wear and tear, etc.

For steam plant progress will probably be along the lines of the application of reheat; an increase of temperatures to the limit for mild steel; with appropriate effect upon pressures; and a general simplification of the power plant aggregate.

British Council's Maps

THE British Council's Map of Europe and the Middle East published by The Royal Geographical Society is one of the most ambitious maps produced by the Society. A detailed description of the map and how it was made was given by Mr. Arthur R. Hinks, whose paper was published in the September 1942 number of the *Geographical Journal*.

The original proposal was made in February 1940, when the British Council required a map in Arabic to show the actual and potential war areas of that time: Europe, Africa and the Middle East. Subsequently it was decided to extend the area eastwards as far as Rangoon.

Murdoch's Third Conical Projection was selected by Mr. Hinks, a projection in which the meridians are perpendicular to the parallels. The map-net was speedily drawn. The lines of longitude are for every 20° from 20° W. to 80° E., and the lines of latitude for every 20° from the Equator to 60° N. Gt. Britain appears more or less upright in the top left-hand corner. The vertical meridian is 17½° E., and the parallels of true length are 55·144° and 26·896°.

The size of the map was determined by the largest plate (38″ × 25″) the photogravure machines of Messrs. Harrison & Sons, Ltd. would take, and it was found that the maximum scale possible for this size map on the projection adopted would be 1/11 millions.

Relief is represented by contours, layer tints and hill-shading. The contours were taken, in the main, from the 1/1 million sheets of the International Map and the 1/4 millions Map of Asia published by the Geographical Section, General Staff, with the addition of the 50 and 100 metre contours. The contours are in brown, the layer-colours various shades of buff, and the hill-shading lavender grey. These aids give a clear picture of the relief of the interior, and bring out the difference between flat and elevated coastlines.

Political boundaries represented by dotted lines in black are those recognized before 1938. Communications are shown in red: the principal railways by a thin single line, and certain selected roads and desert routes by a fine dotted line. Major oilfields and the principal pipe-lines are also shown. The number of towns to be named was naturally limited by the small scale, 1/11 millions (173·6 miles to the inch). They were selected from the principal cities of the densely populated countries and towns of political and historical importance. Care was taken to avoid anything like an even distribution of place-names. The names of the towns are in black and the symbols denoting their position in red.

The map itself is without a frame or border line, and the actual size of the engraved surface 36″ × 23″, leaving a margin of one inch all round to give space for figuring the graticule, scale values along the parallels, etc. The variety of materials used in the preparation of this map includes Aquarelle Board, Bristol Board, Whatman's hot-pressed paper, photographic films and plates 38″ × 27″. Quill pens were used for the lettering, and the map itself was printed by photogravure in six colours on a very strong paper, half linen, half cotton. By using an additional black plate it was possible to produce two editions: (1) the English, and (2) the Arabic. The latter was prepared under the supervision of Professor H. A. R. Gibb. With the extension of the war-zone the preparation of two additional maps became necessary: No, 2, The Far East; and No. 3, North America to Britain. Mr. Hinks and his assistants are to be congratulated on producing a map of exceedingly high merit under the difficult conditions of a World War.

Rats as Scientific Collaborators

IN some experiments in the United States, rats have been treated, not only as passive objects to be operated upon, but as subjects whose own will and judgment was acknowledged as a valuable help in biological research. The proceeding consisted in depriving the rats of some glands, then placing them before a rich menu of various kinds of sugar, salts, fats and carbohydrates, and letting them choose freely what they liked. They chose invariably the food which they needed to keep themselves alive. "The self-selection technique gives us a method of determining chemical and metabolical needs which might be determined by biochemical methods only after prolonged experimentation." This is an acknowledgment made by Curt Richter of the Johns Hopkins Hospital in Baltimore (*Annual Review of Psychology*, 1942, p. 571). He goes on: "With this technique, for instance, we might have determined many years ago, long before the development of modern biochemical methods, that the adrenal glands are concerned with the regulation of sodium metabolism. It would only have been necessary to offer rats a choice of different electrolytes and foods; the immediate selection of electrolytes containing sodium would have shown that the removal of the adrenals had disturbed the sodium metabolism. In the same way this method could have demonstrated that the parathyroid glands are concerned with the regulation of the calcium metabolism, the pancreas with the regulation of the carbohydrate metabolism, and so forth."

It was found that the choice of the rats depended on their sense of taste, not of smell, as had often been assumed.

The degree of sensitivity to salt which is produced by removal of the adrenal glands is astounding. The rats chose a sodium chloride solution in preference to water, even if the concentration were 1:33,000. Richter states as a general rule, that "all the substances, which in some concentrations the rats preferred to water, had a definite nutritional value, while substances which were not preferred to water in any concentration had no nutritional value or were actually poisonous."

It seems even more surprising that the rats should be able to compute the amount of calories they are taking in. But we are told that when the animals were fed on alcohol in different concentrations, they "reduced their food intake directly in proportion to the caloric value of the intake of alcohol, the total caloric intake thus remaining the same."

Stone Age Cultures in North America

A DISCOVERY of considerable moment for the study of the antiquity of man in America is announced in a *communiqué* recently issued by the Smithsonian Institution of Washington. Dr. Frank H. H. Roberts (Jr.), while excavating on behalf of the Institution in eastern Wyoming, has discovered stone spear-heads of the type known to American archaeologists as "Yuma points" in an ancient bison wallow, to which, basing his estimate on the circumstances of discovery, he assigns an antiquity of not more than 2000 to 3000 years. The interest of the discovery lies in the fact that archaeologists have hitherto associated the Yuma point with the implements of the culture of Folsom man—some indeed have considered them of even greater antiquity—although the Yuma point lacks the axial groove running from base to tip which is the characteristic mark of the Folsom points. The Folsom culture which, apart from this possibility, is regarded as the oldest evidence of man's existence in America, is found exclusively on the western side of North America,

mainly in Colorado, Arizona, Texas, and New Mexico, though traces are found so far north as Canada. It was first discovered at Folsom in New Mexico in 1927.

Continued from page 42]

Planning of Science in War and Peace

between British firms of information on penicillin, and the full exchange between this country and America on the subject of anti-malarials. The need for joint consultative committees to stimulate energy in personnel was being recognised, and he quoted the case of a research department where an "efficiency committee" had been formed comprising chemists, laboratory assistants and management representatives on an elected basis.

In the realm of medicine Dr. C. L. Oakley quoted the case of research into gas-gangrene toxins. At the beginning of the war this was being carried out by three different groups, working in isolation on very similar problems. The work was now being done far more effectively as a result of holding an informal conference at which these groups were put in touch with each other.

Mr. G. E. Blackman gave an account of the work of the Biology War Committee, of which he is secretary. This committee was formed last year to ensure that the fullest use is made in the war of biological knowledge and biologists. It had submitted a number of memoranda on various biological problems and these had led to action being taken in many instances, while several Government departments had sent problems to the committee.

Reconstruction

The third session might have been fairly described as "The shape of things to come", but shunning such vicarious aids to capture the public's attention the Association had called it "Determining the future". The chairman, Prof. S. Chapman, president of the Royal Astronomical Society, expressed the view that in the political reconstruction which must come in this country science should be given a greater, more self-conscious and widely recognised part by the State and the people. It should not only influence the legislators: the scientists should be of and among the legislators. He would like to see twenty scientists in the House of Lords.

The first speaker, Professor P. M. S. Blackett, stressed the need for concrete study *now* of what is to be done in the immediate post-war period. In his own words, "Whatever views may be held by individuals about the general question of the desirability or undesirability of more or less planned control of science, a very large number of practical decisions, which will necessarily mould the scientific development of the country for a decade will in fact soon have to be made by someone, somehow, with some objective in view."

Sir Lawrence Bragg gave his views on the position of scientists after the war. He envisaged that in spite of all the interruptions which war had brought to the careers of individual scientists they would gain character and knowledge of the world from their war experience. "We shall have an extremely fine body of scientists after the war, who have grafted knowledge of organisation, of production and of leadership on to their scientific knowledge. If we place these men in the right posts, we can make a splendid contribution to the strength of our country" he commented. In his own field, physics, he hoped that Government research and industry would take full advantage of the supply of technically trained physicists. The Central Register, he believed, was the right body both to watch the conditions and find the man, and he considered it essential that the register should be continued for some years after the war at least, for it represented the inception of a most valuable new scheme. It could solve many problems of post-war rehabilitation, of assessing needs and regulating conditions provided it received the support and advice of scientists as a whole. The most difficult problem in planning the reconstruction of the country was to make full use of our scientific assets, for the position of science in the new world would have to be brought home to politicians and civil servants. "The war has done much to break down barriers and create confidence in the common sense and organising abilities of scientists. If we make wise plans, we have the necessary opening for turning them into realities", he concluded.

Professor Julian Huxley, dealing with the importance of science in colonial development, welcomed the setting up of the Colonial Research Committee and Colonial Products Research Board. Our colonial problem would require urgent consideration after the war; indeed this should not be put off until the end of the war. We had to find a substitute for Imperialism by developing the so-called backward countries in the interests of their inhabitants and, secondly, in the interests of the rest of the world, and raising the colonial peoples as rapidly as possible to the fullest possible degree of self-government. This would take several generations to achieve, and we should give them the utmost encouragement to graft modern techniques, including science, in "an orchestration of cultures throughout the world." In doing so our own scientific knowledge would be enriched in anthropology, pest control and other sciences.

In a challenging speech, Professor H. Levy castigated those scientists whose exaggerated concern for the "freedom" and "purity" of scientific research has earned for them the sobriquet of "the anti-planners". Dr. F. Morgan foresaw an interesting future for operational research by its development into a larger "consumer research". There was nothing new in the idea of efficiency investigations; in America there had been crude "consumer control" depending on research which discriminated between similar branded articles, and commercial firms had carried on market research. In wartime, the war-commodity consumers—the Services—have far greater direct powers over the quality and manufacturers' products than have civil consumers so far in peace time. Operational research protected the consumers' interest. If at the end of the war there was the executive power and the intention to plan in the interests of the ordinary consumers, an "operational research" approach would be automatic and the necessary work carried out through the ministries, local bodies and factory administrations. As an example of its application at municipal level Dr. Morgan suggested a scheme of co-ordinated research to investigate street layout in conjunction with the allied problems of accident rates and street illumination. If the eyes of the layman were opened to the possibilities of consumer control science would at last be fully harnessed to its proper work.

Mr. J. G. Bennett, director of the British Coal Utilisation Research Association, stressed the point that if we were at the stage between research and large-scale production that the control of new processes could be exerted, either by retarding or acceleration. The time lag was considerable; for instance if we decided to produce high octane petrol from coal it would take 15 years to put a plan into operation.

Public Opinion and Scientists

In the discussion which followed many interesting points were raised. Dr. David S. Evans, advisory editor of *Discovery*, argued that the public must be informed of the potentialities of science and that a public opinion must be created capable of informed judgment on social problems of a technical character.

Dr. H. Barron suggested that Britain should endeavour to lead in the coming Plastics Age as it did in the Steel Age, but so far as our home-made plastics were all far too expensive. During wartime we could afford to pay for the special jobs these materials did, but it was imperative that we should obtain cheaper raw materials for their protection. Vision was needed, and he illustrated his point by reference to the production of synthetic rubber in America. It was initially an essential war measure in order to make good the shortage of raw rubber, but as a long-term project it would also ensure an enormous cheap supply of by-products which could be diverted into the plastics industry and thus more than compensate for any extra cost of their rubber.

Corrigenda to p. 16 of Vol. IV No. 1

line 25 : for *atomic weight* read *atomic number*
line 27 : for (3) read (13)
line 32 : for (9) read (26)

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